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PROPOSED MODIFICATION OF YLANG-YLANG OIL STANDARDS [1]

By H. D. GIBBS
(*From the Laboratory of Organic Chemistry, Bureau of Science, Manila, P. I.*)

The ylang-ylang (*Canagium odoratum* Baill.), a medium-sized to rather large tree, is a native of the Malay Archipelago and has been introduced into many other tropical countries for commercial and ornamental purposes.

The essential oil is obtained from the flowers in the Philippine Islands, Indo-China, Java, Siam, New Caledonia, Jamaica, German East Africa, and a number of islands in the vicinity of the last country: namely, Madagascar, Mayotte, Nassi-Bé, and Réunion. The greatest commercial success has been attained in the Philippines and in Réunion on account of the high quality of the product. France takes the largest part of the oil produced in these two places.

The exports for the last five years from the Philippine Islands are given in Table I.

TABLE I.—*Oil exported from the Philippine Islands during the years 1909–1913.*

Year.	Amount.	Value.	
		Total.	Average per kilogram.
	Kilos.	*Pesos.* [a]	*Pesos.* [a]
1909	2,812	175,872	62.54
1910	1,878	116,668	62.12
1911	1,684	94,808	56.30
1912	2,785	161,758	58.08
1913	2,172	116,618	53.70

[a] One peso Philippine currency equals 50 cents United States currency.

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[1] Received for publication January 28, 1915.

The figures for the production prior to 1909 have been tabulated by Bacon.[2] They are considered to be unreliable.

Table I indicates that the foreign sale of ylang-ylang has fallen off and that the average price per kilogram has decreased. The decline is undoubtedly due in part to the competition of other countries, resulting in a diminished demand for second- and third-grade oils. The improved quality and the recent low price of ylang-ylang flowers have also largely eliminated the poorer grades of oil from the local market.

The chemical constituents and chemical properties of ylang-ylang oil have been the subject of numerous investigations.[3] Various attempts have been made to prepare an artificial oil which would displace the true ylang-ylang oil; but on account of the decrease in price of genuine ylang-ylang oil and its real superiority, these attempts have met with very little success.

Bacon[4] found that an oil with a low refractive index, low optical rotation, and high ester number is almost certain to be good; while high refractive index, high optical rotation, and low ester number indicate a poorer grade oil. He states that the ester number of first-grade oils is usually 100 or more, the refractive index is rarely over 1.4900 at 30°, and the optical rotation varies from –32° to –45°, the latter depending on the proportion of sesquiterpenes present. These constants are given in Table II.

TABLE II.—*Classification of ylang-ylang oil according to Bacon.*

Constants.	First grade.	Second grade.
Ester number	100 and above	80 to 100.
Index of refraction	1.4900 and below	Above 1.4900.
Specific rotation	–45° and below	Above –45°.

Two years later Bacon reports[5] that owing to a reduction in the price of flowers to 7 centavos (3.5 cents United States currency) per kilogram better flowers were obtainable, and because of the adoption of improved methods in distillation, oils having an ester number of from 130 to 150 were common.

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[2] *This Journal, Sec. A* (1908), **3**, 65.

[3] Gal, H., *Compt. rend. Acad. sci.* (1873), **76**, 1482; Flückiger, *Arch. d. Pharm.* (1881) (3) **18**, 24; Reychler, *Bull. Soc. chim. Paris* (1894), **11**, 407, 576, and 1045; Dareus, Ibid. (1902), **27**, 83; Schimmel & Co., Semi-annual report (October, 1901), 53; D. R. P. (September, 1901), 142, 859; Bacon, *This Journal, Sec. A* (1909), **4**, 130; and (1910), **5**, 265.

[4] *This Journal, Sec. A* (1908), **3**, 65.

[5] Ibid. (1910), **5**, 265.

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This improvement in quality has continued as evidenced by the constants compiled from data obtained from the oils examined by this laboratory, and given in Table III.

TABLE III.—*Yearly average of constants of ylang-ylang oil for 1910–1914.*

Constants.	Average for—				
	1910	1911	1912	1913	[a]1914
Ester number	114.3	111.0	112.6	122.3	133.2
Index of refraction	1.4918	1.4900	1.4876	1.4925	1.4853
Specific rotation ... degrees	−27.3	−25.7	−32.4	−20.7	−18.9

[a] To July 1, 1914.

Measured by Bacon's standard, the average for each year tabulated in Table III has shown a rise in quality over the averages for the years preceding it. This advance in quality is indicative of the fact, referred to above, of the improvement made by the adoption of better methods in handling and distilling.

In the light of the above tabulation I believe the time is opportune for the introduction of a few changes in the standards for the classification of ylang-ylang oil. Therefore I propose the adoption of a table introduced by Doctor Jahrling of the firm of Santos and Jahrling of Manila. Table IV gives these constants as published by Jahrling.[6]

TABLE IV.—*Classification of ylang-ylang oil according to Jahrling.*

Grade.	Ester number.	Index of refraction.	Specific rotation.	Soluble in alcohol of—
			°	*Per cent.*
Extra	>145	<1.4900	<−35	80
1 a	>120	<1.4950	<−48	90
1 b	>100	<1.4990	<−60	90–96
2	<100	>1.4990	>−60	96

This table really divides what was formerly classed under Class I into three divisions: namely, Extra, 1a, and 1b, depending on the constants shown by the oil. I believe this to be a fair extension of the grading proposed by Bacon, since it makes a distinction among the really high-grade oils and gives the man with an extra-quality oil credit for his efforts.

Schimmel & Co.[7] state that in their experience the best oils have a range of constants as given in Table V.

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[6] *Rev. gén. chim.* (1913), **16**, 43.

[7] Bericht von Schimmel & Co. (October, 1913), 108.

TABLE V.—*Constants of Schimmel & Co.'s best oils.*

Ester number	75 to 120
Index of refraction	1.4910 to 1.5000
Specific rotation	−37° to −57'
Specific weight	0.930 to 0.945

Schimmel & Co. reject the solubility in alcohol as a test for classification. I have found this test very useful as a confirmatory test, since it indicates the amount of sesquiterpenes present in the oil; therefore I have adopted it for use as a standard for classification in this laboratory. This test consists in determining the lowest strength of aqueous alcohol which can be mixed with the oil without cloudiness in the proportion of 2 of oil to 1 of alcohol. Oils with constants superior to those given by Schimmel & Co. are common in the Philippine Islands.

Table VI is a list of constants taken at random from the data collected by the Bureau of Science on the oils examined from January 1, 1913, to July 1, 1914. The table also gives the grade of the oil, classified according to Jahrling's method.

TABLE VI.—*Constants of some samples of ylang-ylang oil examined by the Bureau of Science.*

Grade.	Ester. number.	Index of refraction.	Specific rotation.	Specific gravity.
			°	
Extra	150.73	1.4875	−18.10	0.9509
1 a	133.50	1.4920	−25.90	0.9420
1 b	112.70	1.4935	−32.20	0.9349
1 a	139.06	1.4900	−24.40	0.9432
1 b	115.20	1.4975	−46.20	0.9255
1 a	136.90	1.4940	−31.80	0.9457
Extra	154.90	1.4890	−19.04	0.9519
1 a	141.50	1.4835	−23.80	0.9292
1 a	135.20	1.4890	−26.00	0.9433
1 a	133.10	1.4905	−23.60	0.9410
Extra	154.70	1.4900	−17.50	0.9525
2	61.30	1.5040	−51.40	0.9127
1 a	132.00	1.4900	−21.72	0.9349
1 a	143.00	1.4840	−16.75	0.9417

In our classification we have placed the most emphasis on the ester number as the determining factor, but have been influenced by the other constants.

Doctor Jahrling, of Santos and Jahrling, has very kindly furnished us with a number of samples of oils from his laboratory. The constants of these oils have been determined by the Bureau of Science and are given in Table VII.

TABLE VII.—*Constants of oils submitted by Jahrling.*

Sample No.	Grade.	Ester number.	Index of refraction 30/D.	Specific rotation 30/D.	Specific gravity 30°/30°.	Soluble in alcohol of—
				°		*Per cent.*
1	Extra	201.7	1.4762	− 6.70	0.9478	80
2	1 a	128.7	1.4913	−39.50	0.9445	90
3	Extra	153.8	1.4900	−27.50	0.9504	80
4	1 a	130.3	1.4919	−40.63	0.9452	90
5	Extra	164.4	1.4860	−20.08	0.9564	80
6	Extra	172.7	1.4850	−21.76	0.9579	80
7	1 a	129.9	1.4937	−25.34	0.9472	90
8	1 a	130.0	1.4965	−38.73	0.9450	90
9	1a	124.2	1.4944	−45.95	0.9469	90
10	Extra	157.3	1.4870	−16.23	0.9612	80
11	1 a	122.0	1.4938	−41.83	0.9467	90
12	Extra	148.2	1.4842	−25.80	0.9493	80
13	1 a	122.0	1.4913	−38.73	0.9435	90
14	Extra	157.3	1.4860	−14.12	0.9489	80

Of the 14 oils reported in Table VI, which are representative of the oils received by the Bureau of Science for examination, 11 have ester numbers higher than 120, Schimmel & Co.'s maximum; 9 have indices of refraction less than 1.4910, their minimum index of refraction; while all but two have specific rotation less than the minimum given by this firm.

The oils listed in Table VII show a similar superiority and justify an extension of Bacon's table. All 14 have ester numbers greater than 120, 7 have indices of refraction less than 1.4910, and 8 have specific rotation with a greater negative rotation than −37°.

The average of the constants for the year 1914, from January 1 to July 1, shows this same superiority in all the constants tabulated.

After due consideration of all the above-mentioned facts I believe Jahrling is justified in announcing an extension of the table of constants, as given in Table IV, and that these constants should be adopted as standard for classification.

SUMMARY

The exports in ylang-ylang for the last five years are given.

An extension of the classification at present in use is proposed. This extension is warranted on account of the large number of superior-grade oils produced.

One new test—solubility in alcohol—has been added as a confirmatory test.

PHILIPPINE OIL-BEARING SEEDS AND THEIR PROPERTIES: II[1]

By Harvey C. Brill and Francisco Aggaoili
(From the Laboratory of Organic Chemistry, Bureau of Science, Manila, P. I.)

TWO TEXT FIGURES

The vegetable-oil industry is going through a transition period. Manufacturers and consumers are turning their attention to vegetable oils, and the processes of extraction, expression, refining, and deodorizing have been so greatly improved that these oils have invaded the domain of the animal fats and in many cases entirely usurped their place. In the warmer climates very strong prejudices are held by the Caucasians against the use of animal fats for edible purposes, because of a belief that they are deleterious to the health. This belief is spreading to the native peoples, and the holding of this belief, together with the limited available amount of animal fat, will result in a still more increased demand for edible vegetable oils. The increased demand will be accompanied by a further rise in price, unless larger quantities are available. This gradual rise in cost is illustrated by the table of prices of edible cottonseed oil and edible peanut oil taken from the figures published by a Hamburg importer and quoted by E. W. Thompson.[2]

TABLE I.—*Maximum and minimum prices of cottonseed and peanut oils.*

[Figures give cents per pound.]

	1904	1906	1908	1909	1910	1911	1912
Edible cottonseed oil:							
Lowest	5.06	5.78	6.43	6.27	6.27	7.00	6.93
Highest	6.05	6.60	7.92	8.91	9.24	8.03	8.36
Mean	5.55	6.19	7.17	7.59	7.75	7.51	7.64
Edible peanut oil:							
Lowest			8.80	9.02	9.79	9.57	10.34
Highest			9.02	9.68	10.50	10.78	10.56
Mean			8.91	9.35	10.14	10.17	10.45
Mean difference			1.74	1.76	2.39	2.66	2.81

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[1] Received for publication March 19, 1915.

[2] *Dept. of Commerce, Special Agents Series No. 89.* Part II. Edible oils (1914), 18.

The price of each commodity has generally risen. The mean difference in price has likewise shown a gradual increase. This will result in a greater demand for the less favorably known cottonseed oil. But here the supply is not unlimited. To cite but one instance: Egyptian cotton is suffering severely from the attacks of the pink bollworm that is not only destroying the lint cotton, but is infesting the seed that reaches maturity and goes to the mill as well.

The awakened demand for edible vegetable oils has been accompanied by the withdrawal from the soap industry of such oils as can be made edible by refining, deodorizing, or hydrogenating. Thus many oils formerly used largely or exclusively for the manufacture of soap have now been shifted to this new industry by means of improved treatment in handling, and the soap manufacturers are either unable to obtain them at all or only at greatly inflated prices. To illustrate: Marseilles, which is the most important soap-manufacturing city in Europe, requires annually something like 120,000 tons of fat for this industry. Heretofore 40 per cent of this has been coconut oil. But in recent years, out of the total annual production of 85,000 tons of copra oil in Marseilles, about 50,000 tons are sold direct as an edible fat, and 10,000 tons are exported to the Netherlands and elsewhere for mixing with cottonseed oil, peanut oil, and other soft fats to make oleomargarin; this leaves but 25,000 tons for the soap trade there, when the normal supply from this source has been 48,000 tons.

Linseed oil the last two years has helped somewhat to alleviate this condition. It is easily hardened by hydrogenation, thus making it available for soap stock. And because of the record crop of 1913, when there were 2,700,000 metric tons, or half a million more than the year before, it has been sold at an extremely low price. The cost in Liverpool in April, 1914, was 5.4 cents per pound, or 2 cents cheaper than average tallow. However, the supply of linseed varies from year to year, and the soap industry dares not be entirely dependent on it for its supply of soap stock; consequently any new oil-bearing seeds are eagerly welcomed by importers and manufacturers in the hope that by their exploitation the present strain may be relieved and the price adjusted to the level held before the existing conditions arose.

A preliminary paper on Philippine oil-bearing seeds was published by Richmond and Rosario in 1907.[3] In this article they discussed the nuts known locally as lumbang bato (*Aleurites*

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[3] *This Journal, Sec. A* (1907), 2, 439.

moluccana Willd.), lumbang banucalag (*Aleurites trisperma* Blanco), kapok [*Ceiba pentandra* (L.) Gaertn.] palo maria de la playa (*Calophyllum inophyllum* L.), physic nut (*Jatropha curcas* L.), and the castor-oil seed (*Ricinus communis* L.). The chemical properties and the principal local uses were given by the authors, along with a discussion of the future possibilities of the nuts. Since the publication of the above article, considerable data have been collected regarding some of these nuts and several new ones.

Chisochiton cumingianus (Harms).—This plant is placed in the natural family Melliaceae, the family to which santol belongs. It is of wide distribution in the Philippines, extending from northern Luzon to southern Mindanao, and has been reported by some to be abundant.

The native names recorded are as follows: In Benguet-Union, *batuakan* (Igorot); in Laguna, *balucanag, kalimotani, salaguin;* in Camarines, *balucanag;* in Cagayan, *papalsa, macalsa* (Negrito), and *marambalo* (Cagayan); in Bataan, *cato* (Tagalog); in Albay, *dudos* (Bicol); in Bukidnon, *valita;* in Negros, *malacalad* (Visayan). The use of the name "balucanag" by the natives of Camarines and Laguna would indicate that they recognized the seeds as oil producers, for "balucanag" is properly the name of the oil-producing *Aleurites trisperma* Blanco to which species, however, *Chisochiton cumingianus* has no other point of resemblance.

We have adopted the Tagalog name "cato" to designate this nut and shall refer to it hereafter as the cato nut. The fresh nut is half ellipsoid in shape, averaging 3 centimeters in length and 2.5 centimeters at the widest portion, with a rather hard shell constituting about 60 per cent of the total weight. This shell is somewhat difficult to separate from the meat.

One kilogram of shelled nuts after drying weighed 698 grams and yielded by extraction with petroleum ether 308 grams, or approximately 31 per cent of the whole nut, of a reddish brown oil with a specific gravity of 0.9203 at 15°.5 C. The composition of the dried kernels is given in Table II.

TABLE II.—*Composition of dry cato kernels.*

	Per cent.
Fat (by extraction)	44.12
Protein (N × 6.25)	9.00
Ash	3.19

By expression the dry kernel gave 35.56 per cent oil. The oil has a rancid odor, is nondrying, and has purgative properties.

We are indebted to Prof. A. G. DuMez, director of the School of Pharmacy of the University of the Philippines, and Doctor de la Paz, of the University of the Philippines, for the examination of its physiological properties. They report:

> Administered to cats in doses of 0.34 cubic centimeter per 500 grams body weight the effect was very slight, apparently causing a movement of the bowels within eight hours in 2 cases out of the 5 tried; when given in larger doses, 1.70 cubic centimeters per 500 grams body weight, the 3 cats treated were all affected within twelve hours of the administration of the dose, and the first movement was followed by successive movements within the twenty-four hours; doses of 3.34 cubic centimeters of cato oil for 500 grams body weight caused vomiting in both cases within the three hours following the administration of the dose.

The laxative effect of cato is weaker, however, than that of castor oil, 5 parts of cato oil being approximately equivalent to 1 part of castor oil. Its soap-making qualities were tested by the Bureau of Science with gratifying results, and it is now being used by at least one firm in Manila in this industry.

The chemical constants are given in Table III.

TABLE III.—*Chemical constants of cato oil.*

Specific gravity at 15° C.		0.9203
Specific gravity at 30° C.		0.9188
Butyro refractometer (reading at 30° C.)		60–61
Iodine value (Hanus)		80.78
Reichert-Meissl value		7.34
Saponification number		192.02
Free fatty acids (oleic)	per cent	3.98
Acid value	cc. N/10 KOH	7.06

Sterculia fœtida L.—*Sterculia* is a genus of the Sterculiaceae—the cacao or calumpang family—and is represented by many species in the tropics of both hemispheres. *Sterculia fœtida* occurs in eastern Africa to India, through Malaya to northern Australasia, and throughout the Philippines. It is known locally as calumpang (Tagalog, Pampanga); *bangar* (Ilocano); and *bobog* (Visayan). The follicles are large and woody, about 10 centimeters long, and contain from 10 to 15 seeds. The shells constitute approximately 48 per cent of the whole seed. The name calumpang is used to designate it throughout this paper.

The seeds are edible, but are slightly purgative when eaten in quantities. The composition of dried seeds examined by the Bureau of Science is given in Table IV.

TABLE IV.—*Calumpang dry shelled seeds.*

	Analysis by—	
	Bureau of Science.	Bolton and Jesson.[a]
	Per cent.	*Per cent.*
Fat (by extraction of dry seeds)	51.78	52.0
Protein (N×6.25)	21.61	
Starch	12.10	
Sugars	5.00	
Cellulose etc. (by difference)	5.61	
Ash	3.90	

[a] *Analyst* (1915), 40, 3.

The chemical constants of the oil are as follows:

TABLE V.—*Chemical constants of calumpang oil.*

	Analysis by—	
	Bureau of Science.	Bolton and Jesson.
Specific gravity at 30° C	0.9254	
Butyro refractometer reading at 40° C	63–64	59.8
Iodine value (Hanus)	76.04	75.8
Reichert-Meissl value	2.10	
Saponification number	212.01	193.7
Free fatty acids (oleic) per cent	0.45	1.0
Acid value cc. N/10 KOH	0.30	

The oil is a bland, sweet oil with a comparatively high melting point and is light yellow in color. Prof. A. G. DuMez has examined the oil for its physiological properties. He states:

> The oil appears to resemble olive oil very much in its physiological action. Administered to dogs in doses of 1.5 to 3 cubic centimeters per kilogram body weight, it acts as a mild laxative. It is nontoxic and has no irritating action. It can be used in the same manner as olive oil and should be especially useful for culinary purposes.

Canarium pachyphyllum Perk.—The genus *Canarium* is widely distributed in the Philippine Islands and is represented by many species. The pili nut of commerce comes from some of these. The Tagalog name is *pagsainguin*. Two varieties of nuts from *Canarium pachyphyllum* were examined by us, the long and the short variety. Their description is given in Table VI:

TABLE VI.—*Description of two varieties of pili nuts.*

	Long.	Short.	*Canarium luzonicum.*[a]
Length ....cm..	6 - 6.75	4.5 - 5	[b]4.5-6
Greatest width of triangular cross section ....do...	2.25- 2.5	2.25- 2.5	2
Average weight of nuts ....grams..	8.67	9.44	9.30
Shell ....per cent..	81.13	81.71	....
Kernel ....do...	18.87	18.29	....
Fat ....do...	14.03	13.27	....

[a] Bolton and Jesson, loc. cit.

[b] The nuts described here are doubtless from *Canarium pachyphyllum* and not *Canarium luzonicum*. The nuts of the latter are much smaller and are not available in any quantity.

The composition of the kernels is given in Table VII.

TABLE VII.—*Composition of the kernels of pili nuts.*

	Long.	Short.	*Canarium luzonicum.*[a]
	Per cent.	*Per cent.*	
Moisture	2.79	2.90	....
Fat	74.39	72.53	72.20
Protein (N × 6.25)	12.06	11.88	....
Sucrose	0.88	0.66	....
Reducing sugars	0.45	1.35	....
Starch (by difference)	4.33	5.11	....
Crude fiber	2.15	2.42	....
Ash	2.97	3.15	....

[a] Bolton and Jesson, loc. cit.

The oil is bland, sweet, and suitable for salad and other culinary purposes; however, two objectionable features prevent its becoming an important article of commerce: namely, the high percentage and hardness of the shell. Table VIII gives the constants found for the pure dry oil.

TABLE VIII.—*Chemical constants of pili oil.*

	Long.	Short.	*Canarium luzonicum.*[a]
Specific gravity at 30° C	0.9067	0.9067	....
Butyro refractometer reading at 30° C	54-54.2	54-54.2	[b]48.6
Iodine value (Hanus)	61.25	59.61	57.10
Reichert-Meissl value	3.3	2.2	....
Saponification number	192.6	186.8	197.0
Free fatty acids (oleic) ....per cent..	7.62	8.84	1.44
Acid value ....cc. N/10 NaOH..	2.70	3.13	....

[a] Bolton and Jesson, loc. cit.

[b] At 40° C.

EXAMINATION OF THE DRYING PROPERTIES OF VARIOUS PHILIPPINE OILS

Richmond and Rosario[4] had planned to examine the oils of the Philippines for their drying qualities, but for various reasons were unable to do so. A great deal of interest is shown in drying oils by manufacturers, because of the wide and varied uses to which such oils are put. On this account we have made a rather extensive examination of the drying qualities of these oils and a critical study of some special tests for their distinction.

TABLE IX.—*Solubility of Philippine vegetable oils in alcohol and ether.*

Botanical name.	Local name.	Solubility of oil in—		
		Absolute alcohol.	90 per cent alcohol.	Ethyl ether.
Sterculia fœtida	Calumpang	Insoluble (1-4)	Insoluble	Not so readily.
Chisochiton cumingianus.	Cato	Soluble (1-1)	do	Easily.
Aleurites moluccana	Lumbang bato	Insoluble (1-4)	do	Do.
Aleurites trisperma	Lumbang banucalag.	Soluble (1-1)	do	Do.
Ceiba pentandra	Kapok	Insoluble (1-4)	do	Do.
Canarium pachyphyllum.	Pili	do	do	Do.
Calophyllum inophyllum.	Palo maria de la playa.	Soluble (1-1)	do	Do.
Calophyllum wallichianum.	Palo maria del monte.	do	do	Do.

This scheme would make it possible to distinguish lumbang bato from lumbang banucalag, since the former is insoluble in absolute alcohol in the proportion of 1 to 4, while the latter is soluble in the proportion of 1 to 1.

Aleurites moluccana and Aleurites trisperma.—These oils, known locally as lumbang bato and lumbang banucalag, respectively, have been discussed by Richmond and Rosario.[5]

A good deal of contradictory information has been recorded in the literature in regard to the properties of the press cake. Drury, Useful Plants, has this statement:

> The cake, after expression of the oil, is a good food for cattle, and useful as manure.

The United States Dispensatory states:

> The cake left after the expression of the oil, given to a dog in the dose of about half an ounce produced no vomiting, but acted strongly as a purgative.

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[4] Loc. cit.

[5] Loc. cit.

TABLE X.—*Reactions of Philippine vegetable oils with nitric and sulphuric acids.*

Local name.	Nitric acid.	Sulphuric acid.	Mixture of nitric and sulphuric acids.
Calumpang	Golden yellow; limpid	Dark red; thickens	Yellow-brown; thickens.
Cato	Yellow-brown; limpid	Brownish red; thickens somewhat	Almost black; thickens somewhat.
Lumbang bato	Cherry-colored; limpid	Red-brown; viscous	Cherry brown; limpid.
Lumbang banucalag	Yellow-brown; viscous	Red-brown; semiviscous	Brown (darker than above); viscous.
Kapok	Light yellow; limpid	Dark yellowish red; almost solid	Deep red; limpid.
Pili	Golden yellow; limpid	Brownish red; thickens somewhat	Same as with nitric acid.
Palo maria de la playa	Orange; limpid	Red; thickens somewhat	Brown; thickens slightly.
Palo maria del monte	Reddish yellow; limpid	Darker than above; semiviscous	Yellowish brown; limpid.

The Agricultural Gazette of New South Wales[6] claims that the press cake is poisonous to cattle. Mr. D. S. K. Pahu, a native of the Hawaiian Islands, employed in the Executive Bureau of the Insular Government here, informed us that the lumbang nut, known in the Hawaiian Islands as the kukui nut, is considered a delicacy when roasted and is eaten without deleterious results in this condition, but that when eaten in the fresh state it has strong physiological properties, causing nausea and dizziness. Guthrie and Ramsay[7] announce:

> It is a drying oil and is used in the arts for the same purposes as linseed oil, and for burning. * * * It is used medicinally as a plaster and as an article for diet—as olive oil is used.

On the other hand, the Chinese, who are the greatest dealers in this commodity in Manila, affirm that the oil cannot be used for culinary purposes on account of its causing dizziness and nausea. We have tested the heated press cake and the extracted press cake by feeding chickens with each for intervals of ten days with no harmful results to the fowls.

Most of this oil is expressed by the Chinese by means of crude, wooden hand presses, having a capacity of about 800 grams. One small factory can express about 75 liters of oil per day; but as less than 20 per cent of the total oil is extracted, much is going to waste. At present it sells at approximately 12 centavos (6 cents United States currency) per pound in Manila.

In 1911 the United States imported 5,000,000 gallons of Chinese wood oil from China. This oil is used extensively for special varnishes and linoleum and for other similar purposes. This oil is so highly appreciated by the United States paint concerns that 40,000 trees have been planted in the Southern States. These are expected to furnish from one fourth to one third of the present supply of tung oil in the United States when they reach maturity.[8] We believe either of the lumbang oils could be substituted for tung oil, as they are quick-drying, giving a clear, transparent, nonsticky film on a surface when exposed to the air for a short time. Thrum[9] says:

> The last use, to our knowledge, made of it in house painting here was at the construction of the Judd building about 1855, by R. Gilliland, who is said to have made the statement that it was good for fifteen to twenty years.

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[6] *Agr. Gaz. N. S. W.* (1906), 17, 859.

[7] Ibid. (1906), 17, 859.

[8] *Drugs, Oils and Paints* (1914), 30, 207.

[9] *Hawaiian Annual* (1893), 107.

The following statement occurs in the Bulletin of the Imperial Institute,[10] London:

> Kukui (Lumbang bato) oil belongs to the drying oils typified by linseed—suitable for soap, oil-varnishes, paints, linoleum, and other similar purposes.

Lumbang banucalag oil, allowed to stand at room temperature in an extraction flask exposed to the air for some time, became viscous and later settled to a clear straw-yellow gum, which was insoluble in alcohol and kerosene, but soluble in turpentine and alcoholic potash. The turpentine solution dried to a thin transparent film when exposed on a glass plate in the course of a few hours.

Lumbang banucalag, lumbang bato, and cato oils were placed in small flasks on the steam bath, and dry air was passed through them. The flasks were weighed at intervals, and the change in weight was determined. This percentage change, marked − where a loss was found and + where the oil gained in weight, is recorded in Table XI.

TABLE XI.—*Change in weight of lumbang and cato oils when blown at a temperature of 100° C.*

Serial No.	Time.	Lumbang banucalag.	Lumbang bato.	Cato.
	Hours.	*Per cent.*	*Per cent.*	*Per cent.*
1	1	−3.80	−4.66	−0.32
2	2	−3.98	−4.85	−0.38
3	3	−3.99	−4.98	−0.38
4	4	−4.01	−5.02	−0.35
5	5	−3.95	−5.03	−0.32
6	6.5	−3.86	−4.81	−0.06
7	9.5	−3.79	−4.26	−0.05
8	12.5	−3.62	−3.96	+0.01
9	16.5	−3.51	−3.38	+0.21
10	21	−2.81	−2.30	+0.45
11	22.5	−2.70	−2.29	+0.47
12	28.5	−1.75	−1.89	+0.48
13	31	−1.25	−1.54	+0.50
14	34	−0.93	−1.30	+0.51
15	36	−0.64	−1.00	+0.52

The lumbang oils show a maximum loss in weight at the end of the fourth hour; thereafter the weight increases steadily.

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[10] *Bull. Imp. Inst.*, London (1907), 5, 136.

At the end of the experiment both had become thick and gummy with none of the original oily appearance, while cato oil, on the other hand, showed very little change in its weight and practically no difference in its physical properties when treated thus. The above oils were heated to 270° C. and held there for fifteen minutes. The sample of lumbang bato used suffered a loss of 1.5 per cent in weight, but showed no deposit of foots on cooling; lumbang banucalag lost 0.8 per cent and showed a slight deposit of foots; cato oil lost 1.6 per cent of its original weight and deposited a small amount of foots when allowed to stand. All three darkened somewhat. Seventy-five hundredths per cent precipitated lead and 0.75 per cent manganese borate were added to each, and they were then heated on the water bath for three hours. Only a part of the dryer went into solution, but the effect on the lumbang oils was decidedly marked. When the "boiled" oils were spread evenly on glass plates and placed in a horizontal position in a box protected from dust in subdued light at room temperature, lumbang banucalag oil dried to a clear film in five hours, while lumbang bato oil underwent a like change in six hours. Cato oil did not dry and at the end of twenty days remained wet and without having undergone any noticeable change in consistency. These experiments demonstrate that the lumbang oils are drying oils of good quality and capable of taking a dryer; cato oil, on the other hand, shows no improvement when treated thus.

Further drying tests were arranged for the native oils under conditions approximating those existing when the oil is used for painting purposes, to determine the rate of drying and the change in weight. These changes are demonstrated in figs. 1 and 2. The oils were spread evenly on glass plates 7.5 by 4 inches in size, previously weighed and again weighed when covered with the oil film. They were then placed in a horizontal position on racks in boxes, the sides of which were made of a good quality of cheese cloth. This prevented the entrance of dust, insects, etc., but allowed a free passage of air. They were weighed each morning. Duplicates were run in all cases, and the average result is plotted. In figs. 1 and 2 the time in days is plotted along the horizontal axis and the per cent increase along the vertical axis.

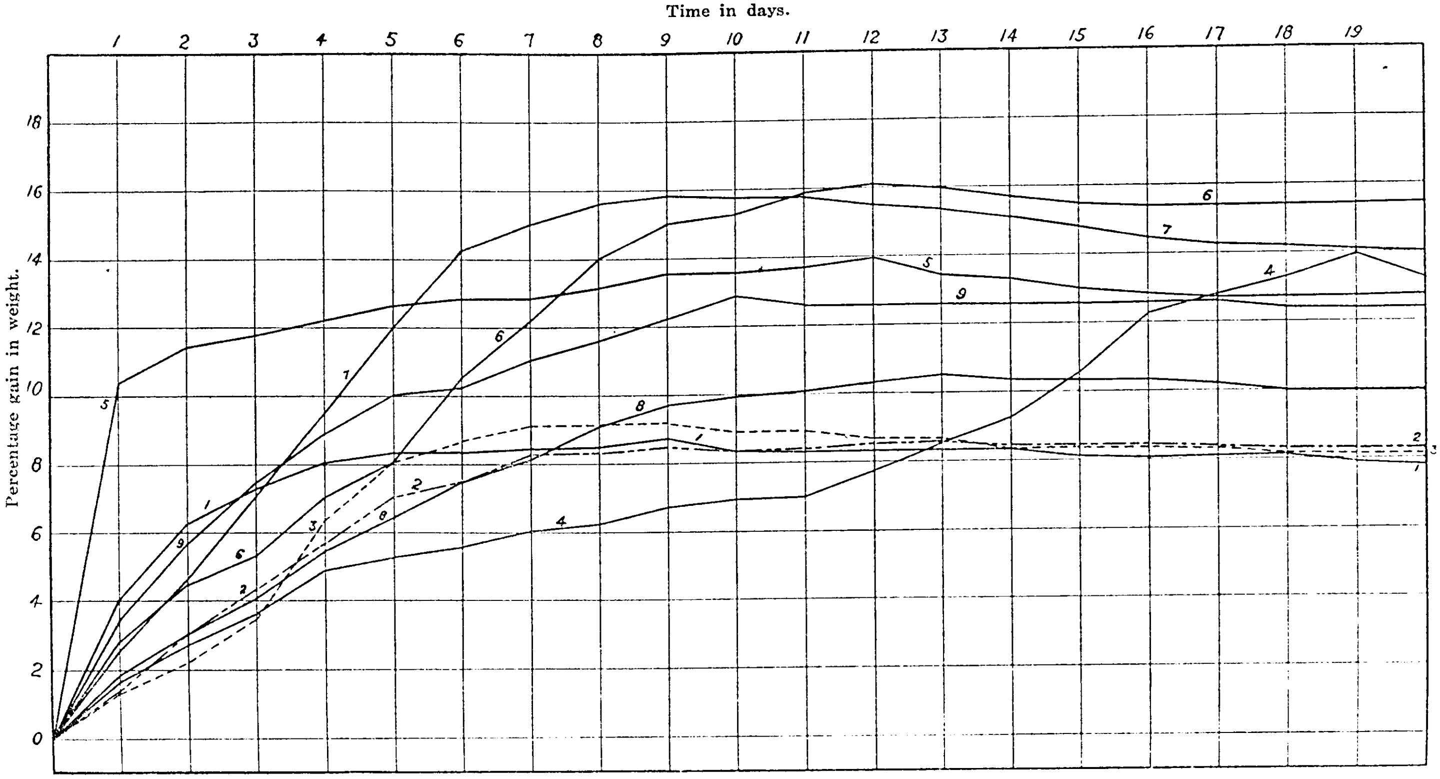

FIG. 1. For description of the curves see Table XII.

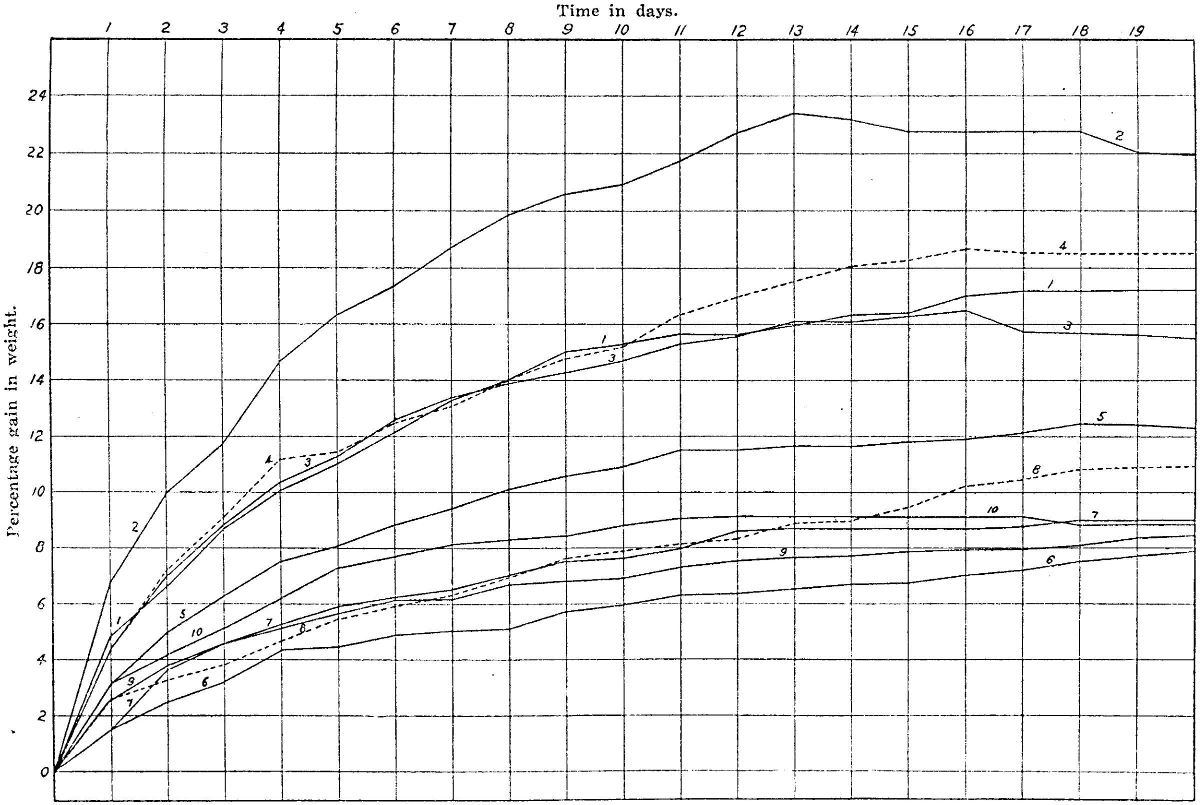

FIG. 2. For description of the curves see Table XIII.

TABLE XII.—*Description of oils of fig. 1.*

Curve.	Oil.	Condition.	Day when crest is reached.	Maximum increase in weight.	Day when maximum is reached.	Day when film is dry.	Condition of film at end of 20 days.
				Per ct.			
1	Lumbang bato	Bottled 2 years; heated for 3 hours at 100° C. before use.	4- 5	8.76	9	6	Clear, firm.
2	Lumbang banucalag.	do	6- 7	8.59	11	5	Do.
3	do	Bottled 2 years	6- 7	9.18	9	5	Do.
4	do	Freshly expressed	16-19	13.98	19	13	Clear, slight tackiness.
5	Linseed, "boiled"	Commercial sample.	1- 4	13.96	12	4	Clear, firm.
6	Lumbang bato	Freshly expressed	9-12	16.09	12	8	Do.
7	do	Bottled 2 years	6- 9	15.91	9	7	Do.
8	do	Bottled 2 years; heated for 15 minutes at 270° C. before use.	7- 9	10.50	13	6	Do.
9	Lumbang banucalag.	do	8-10	12.90	10	5	Slight cloudiness, firm.

TABLE XIII.—*Description of oils of fig. 2.*

Curve.	Oil.	Condition.	Day when crest is reached.	Maximum increase in weight.	Day when maximum is reached.	Condition of film at end of 20 days.
				P. ct.		
1	Pili	Freshly extracted; heated for 3 hours at 100° C. before use.	10	17.22	17	Slightly thickened, not dry.
2	Cato	Freshly extracted	13	23.42	13	Do.
3	do	Freshly extracted; heated for 3 hours at 100° C. before use.	13	16.52	16	Slightly thicker than 2.
4	Palo maria de la playa.	Bottled 2 years	14	18.66	16	No appreciable change.
5	Palo maria del monte.	do	11	12.46	18	Do.
6	Palo maria de la playa.	Bottled 2 years; heated for 3 hours at 100° C. before use.	11	7.86	20	Do.
7	Palo maria del monte.	do	12	9.00	18	Do.
8	Calumpang	Freshly extracted	16	10.91	19	Slightly thickened.
9	Kapok	Bottled 2 years; heated for 3 hours at 100° C. before use.	8	8.46	20	Considerably thickened.
10	Cato	Freshly extracted; heated at 270° C. for 15 minutes before use.	7	9.18	12	Do.

Redman, Weight, and Block[11] have determined the drying rates of linseed, china wood, fish, and soya bean oils. Raw linseed oil reached a maximum increase in weight of 11.7 per cent at the end of the sixth day; china wood oil shows an increase of 10.5 per cent between the eighth and ninth days; the fish oils show an increase of 13 per cent between the third and fourth days; while soya bean oils show an increase of 7.7 per cent between the sixth and seventh. (Compare with the results as recorded in Table XII). Lippert[12] gives the increase for raw linseed oil as 12.4 per cent on drying. Meister[13] says that china wood oil is slower in absorbing oxygen than linseed oil, and although the film forms in from one to two days it does not become firm until the fifth or sixth. The lumbang oils compare very favorably with china wood oil and linseed oil in rate of drying, quality of film, and the per cent change in weight when drying. The results of these investigators are especially interesting in comparison with the results obtained by us as set forth in Tables XII and XIII.

SUMMARY

The percentage yields, chemical constants, physiological properties, and commercial possibilities of cato, calumpang, and pili nut oils have been given and discussed.

An investigation of the drying qualities of the oils from the nuts of calumpang, cato, lumbang bato, lumbang banucalag, kapok, pili, palo maria de la playa, and palo maria del monte is recorded, demonstrating that lumbang bato and lumbang banucalag are drying oils of high quality, comparing favorably with linseed and china wood oils, and that the others have no appreciable drying qualities.

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[11] *Journ. Ind. & Eng. Chem.* (1913), **5**, 630.

[12] *Journ. Franklin Inst.* (1899), 156.

[13] *Journ. Soc. Chem. Ind.* (1911), **30**, 95.

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. *Curve 1.* Lumbang bato oil, bottled two years, heated for three hours at 100° C. before use.

Curve 2. Lumbang banucalag oil, bottled two years, heated for three hours at 100° C. before use.

Curve 3. Lumbang banucalag oil, bottled two years.

Curve 4. Lumbang banucalag oil, freshly expressed.

Curve 5. Linseed oil, "boiled," commercial sample.

Curve 6. Lumbang bato oil, freshly expressed.

Curve 7. Lumbang bato oil, bottled two years.

Curve 8. Lumbang bato oil, bottled two years, heated for fifteen minutes at 270° C. before use.

Curve 9. Lumbang banucalag oil, bottled two years, heated for fifteen minutes at 270° C. before use.

2. *Curve 1.* Pili oil, freshly extracted, heated for three hours at 100° C. before use.

Curve 2. Cato oil, freshly extracted.

Curve 3. Cato oil, freshly extracted, heated for three hours at 100° C. before use.

Curve 4. Palo maria de la playa oil, bottled two years.

Curve 5. Palo maria del monte oil, bottled two years.

Curve 6. Palo maria de la playa oil, bottled two years, heated for three hours at 100° C. before use.

Curve 7. Palo maria del monte oil, bottled two years, heated for three hours at 100° C. before use.

Curve 8. Calumpang oil, freshly extracted.

Curve 9. Kapok oil, bottled two years, heated for three hours at 100° C. before use.

Curve 10. Cato oil, freshly extracted, heated at 270° C. for fifteen minutes before use.

THE ENZYMES OF CACAO[1]

By Harvey C. Brill

(From the Laboratory of Organic Chemistry, Bureau of Science, Manila, P. I.)

The necessity for fermenting or sweating cacao is now generally acknowledged. The principal changes brought about by this process are: (1) The removal of the greater portion of the sugary pulp or parenchymatous tissue surrounding the beans, (2) the dissociation of the bean from its testa or seed coat, (3) the promotion of chemical changes within the seeds, (4) the conversion of the bitter astringent taste into a palatable sweet one, and (5) an improvement in color, break, and flavor.

Investigators are not agreed as to the cause of these changes and attribute them to the action of various agencies. Hart[2] contends that the process of—

> fermentation or sweating in cacao consists in an alcoholic fermentation of the sugars in the pulp of the fruit accompanied by a loss of some of the albuminoid and indeterminate nitrogenous constituents of the beans. * * * Some parts of the carbohydrates other than sugars undergo hydrolysis and either escape in the runnings from the boxes in the form of glucose, or undergo in turn the alcoholic and acetic fermentations. During this change some of the astringent matters to which the somewhat acrid taste of the raw beans is due are also hydrolised, and thus a marked improvement in flavour is gained.

Harrison[3] holds the same view.

A. Schulte im Hofe,[4] in an investigation carried out at Victoria in Cameroon, came to the conclusion that the changes brought about in the cacao bean during fermentation were the result of an oxidation process and were precisely similar to those taking place during the conversion of green tea into black tea. He made no attempt to determine if the oxidation was due to the action of enzymes or arose from other causes.

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[1] Received for publication February 26, 1915.

[2] Cacao. Trinidad, 2d ed. (1900), 106–107.

[3] *Proc. Agr. Soc. Trinidad* (1896–97), 2, 250.

[4] Die Kultur und Fabrication von Tee in Britisch Indien und Ceylon mit Rücksicht auf den wirtschaftlichen Wert der Teekultur für die deutschen Kolonien. *Tropenpflanzer* (1901), 5 (2), 37.

That the fermentation is the result of biological action is the conclusion of J. Sack.[5]

Preyer[6] has isolated a yeast, *Saccharomyces theobromæ,* from fermenting cacao and has recommended the use of the pure culture of this for the initiation of the fermentation. Besides the above he observed *S. cerevisiæ, S. ellipsoidies,* and *S. membranaefaciens* in fermenting cacao. Others have noted the presence of *Penicillium* and *S. apiculatus.*

However, not much success has been attained with the use of pure cultures of yeasts, and not much development can be looked for along this line, since the use of a pure strain of yeast would necessitate the sterilization of the culture medium, the cacao. Sterilization would destroy the enzymes present. Behrens[7] has pointed out that the changes desired from fermentation do not occur when the enzymes are destroyed.

That the color change in the bean from white or violet to brown is only indirectly produced by fermentation is maintained by Loew.[8] He insists that the brown coloration is due to the action of the oxidases or oxidizing enzymes, since this same brown coloration is produced when the beans are crushed and exposed to the air. These oxidases are stored up in the protoplasm of the bean of the cell and are liberated when the cells are killed, without injury to the enzyme. The enzyme then becomes active.

It is a very generally accepted belief that enzymes are an important factor in the changes tobacco undergoes during the curing process. With this in mind Oosthuizen and Shedd[9] have investigated the enzymes of the tobacco plant.

Many plants and plant products[10] are being investigated to discover the enzymes present and thus throw some light on the changes they undergo when ripening and germinating and their influence on the system when used for foods.

On account of the great interest manifested in enzymology and in the hope that some light may be thrown on the cause of the changes taking place in the fermentation of cacao and on the real nature of the changes themselves, this investigation has been undertaken.

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[5] H. H. Smith, The Fermentation of Cacao. John Bale Sons and Danielsson, London (1913), 138–141.

[6] *Tropenpflanzer* (1901), 5, 151.

[7] Lafar, Handbuch der technischen Mykologie, 1, 655.

[8] *Porto Rico Exp. Sta. Rep.* (1907).

[9] *Journ. Am. Chem. Soc.* (1913), 35, 1289.

[10] Chelpin, General Chemistry of the Enzymes. Trans by Pope. John Wiley & Sons (1912).

EXPERIMENTAL

A 10 per cent aqueous solution of the pulp and seed of cacao was made by grinding them in a mortar with clean sand under water, allowing them to stand two hours, and afterwards filtering through cheese cloth. The seed was freed from the pulp and surrounding slime by very careful washing in running water and later removal of the inclosing membrane. Three series of experiments were run: namely, with the surrounding pulp, the fresh clean seed, and the clean fermented seed. The last was prepared by placing the seed in the incubator and allowing the process of fermentation to proceed for four days. It was then removed, very carefully separated from the outer slime and surrounding membrane, and treated as the other two. In all cases toluene was used as the antiseptic.

Tests were then carried out with these solutions for the detection of enzymes.

TABLE I.—*Tests for lipase.*

SERIES 1.

	Cc. N/10 NaOH.
15 cc. water, 10 cc. pulp extract, 48 hours at 38° C	0.40
15 cc. water, 10 cc. pulp extract, 1 cc. olive oil, 48 hours at 38° C	0.45
15 cc. water, 10 cc. pulp extract heated, 1 cc. olive oil, 48 hours at 38° C	0.42
25 cc. water, 1 cc. olive oil, 48 hours at 38° C	0.45

SERIES 2.

16 cc. water, 10 cc. seed extract, 48 hours at 38° C	0.40
15 cc. water, 10 cc. seed extract, 1 cc. olive oil, 48 hours at 28° C	0.40
15 cc. water, 10 cc. seed extract heated, 1 cc. olive oil, 48 hours at 38° C	0.45

SERIES 3.

10 cc. water, 10 cc. fermented seed extract, 48 hours at 38° C	0.72
15 cc. water, 10 cc. fermented seed extract, 1 cc. olive oil, 48 hours at 38° C	0.72
15 cc. water, 10 cc. fermented seed extract heated, 1 cc. olive oil, 48 hours at 38° C	0.78

No lipase was present that reacted on olive oil, as the control required the same amount of N/10 NaOH for neutralization as the active sample. Duplicates of the above were carried out substituting ethyl butyrate for olive oil with the like negative results.

TABLE II.—*Tests for emulsin.*

SERIES 1.

	Test for—		
	Glucose.	Hydrocyanic acid.	Benzaldehyde.
10 cc. water, 10 cc. pulp extract, 48 hours at 38° C	[a] ++	—	—
10 cc. amygdalin solution, 10 cc. pulp extract, 48 hours at 38° C	++	—	
10 cc. amygdalin solution, 10 cc. pulp extract heated, 48° C	++	—	—
10 cc. amygdalin solution, 10 cc. pulp water, 48 hours at 38° C	—	—	—

SERIES 2.

	Glucose.	Hydrocyanic acid.	Benzaldehyde.
10 cc. water, 10 cc. seed extract, 48 hours at 38° C	—	—	—
10 cc. amygdalin solution, 10 cc. seed extract, 48 hours at 38° C	—	—	—
10 cc. amygdalin solution, 10 cc. seed extract heated, 48 hours at 38 °C	—	—	—

SERIES 3.

	Glucose.	Hydrocyanic acid.	Benzaldehyde.
10 cc. water, 10 cc. fermented seed extract, 70 hours at 38° C	—	—	—
10 cc. amygdalin solution, 10 cc. fermented seed extract, 70 hours at 38° C	—	—	—
10 cc. amygdalin solution, 10 cc. fermented seed extract heated, 70 hours at 38° C	—	—	—

[a] + means slight test, + + means fair test, + + + means good test, + + + + means strong test, wherever used in this paper.

The amygdalin solution was a 10 per cent solution in water. The results of the tests for emulsin with amygdalin were in all cases negative. A test for glucose was obtained in series 1, but this positive test was due to the presence of invert sugar in the original pulp. The tests for hydrocyanic acid and benzaldehyde were negative in all cases. This is different from the results obtained by J. Sack,[11] who claims to have obtained a splitting of amygdalin by the enzymes in cacao.

TABLE III.—*Tests for casease.*

SERIES 1.

	Cc. N/10 NaOH.	Tryptophane reaction.
20 cc. water, 10 cc. pulp extract, 48 hours at 38° C	0.05	—
20 cc. casein solution, 10 cc. pulp extract, 48 hours at 38° C	1.60	+
20 cc. casein solution, 10 cc. pulp extract heated, 48 hours at 38° C	0.35	—
20 cc. casein solution, 10 cc. water, 48 hours at 38° C	0.35	—

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[11] H. H. Smith, The Fermentation of Cacao, 148.

TABLE III.—*Tests for casease*—Continued.

SERIES 2.

	Cc. N/10 NaOH.	Tryptophane reaction.
20 cc. water, 10 cc. seed extract, 48 hours at 38° C	0.05	—
20 cc. casein solution, 10 cc. seed extract, 48 hours at 38° C	0.75	+
20 cc. casein solution, 10 cc. seed extract heated, 48 hours at 38° C	0.25	—

SERIES 3.

	Cc. N/10 NaOH.	Tryptophane reaction.
20 cc. water, 10 cc. fermented seed extract, 70 hours at 38° C	0.05	—
20 cc. casein solution, 10 cc. fermented seed extract, 70 hours at 38° C	1.05	+
20 cc. casein solution, 10 cc. fermented seed extract heated, 70 hours at 38° C	0.65	—
20 cc. casein solution, 10 cc. water, 70 hours at 38° C	0.65	—

This 5 per cent casein solution was made by grinding casein under water, neutralizing with N/10 NaOH, making up to the mark, allowing it to stand overnight at a temperature of 38° C., and filtering.

The amino acids were titrated by the method of Sorensen.[12]

There is evidence of the presence of a proteolytic enzyme which hydrolyzes casein. This is more evident in series 1 and 3; but as the active sample in all cases required more NaOH for neutralization than was needed for the controls, the proof of the presence of a casease is fairly conclusively established.

TABLE IV.—*Tests for albuminase.*

SERIES 1.

	Cc. N/10.	Tryptophane test.
25 cc. water, 10 cc. pulp extract, 72 hours at 38° C	0.05	—
25 cc. egg albumin solution, 10 cc. pulp extract, 71 hours at 38° C	0.75	[a] +
25 cc. egg albumin solution, 10 cc. pulp extract heated, 71 hours at 38° C	0.50	—
25 cc. egg albumin solution, 10 cc. water, 71 hours at 38° C	0.60	—

SERIES 2.

	Cc. N/10.	Tryptophane test.
25 cc. water, 10 cc. seed extract, 72 hours at 38° C	0.05	—
25 cc. egg albumin solution, 10 cc. seed extract, 72 hours at 38° C	0.55	—
25 cc. egg albumin solution, 10 cc. seed extract heated, 72 hours at 38° C	0.40	—

SERIES 3.

	Cc. N/10.	Tryptophane test.
25 cc. water, 10 cc. fermented seed extract, 75 hours at 38° C	0.05	—
25 cc. egg albumin solution, 10 cc. fermented seed extract, 75 hours at 38° C	1.20	—
25 cc. egg albumin solution, 10 cc. fermented seed extract heated, 75 hours at 38° C	0.95	—

[a] Very faint.

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[12] *Biochem. Zeitg.* (1887–88), 7, 45.

Albuminases are probably absent in cacao or, at least, so feebly active as to be negligible in so far as their influence on the fermentation may be concerned.

TABLE V.—*Tests for protease.*

SERIES 1.

	Cc. N/10.	Trytophane test.
20 cc. water, 10 cc. pulp extract, 48 hours at 38° C	0.05	—
20 cc. peptone solution, 10 cc. pulp extract, 48 hours at 38° C	2.20	+
20 cc. peptone solution, 10 cc. pulp extract heated, 48 hours at 38° C	1.20	—
20 cc. peptone solution, 10 cc. water, 48 hours at 38° C	1.05	—

SERIES 2.

20 cc. water, 10 cc. seed extract, 48 hours at 38° C	0.05	—
20 cc. peptone solution, 10 cc. seed extract, 48 hours at 38° C	1.10	—
20 cc. peptone solution, 10 cc. seed extract heated, 48 hours at 38° C	1.05	—

SERIES 3.

20 cc. water, 10 cc. fermented seed extract, 74 hours at 38° C	0.05	—
20 cc. peptone solution, 10 cc. fermented seed extract, 74 hours at 38° C	2.00	+
20 cc. peptone solution, 10 cc. fermented seed extract heated, 74 hours at 38° C	1.10	—

The peptone solution used was a 2 per cent solution of Witte peptone in water.

Judging from the tryptophane test and the difference in number of cubic centimeters of NaOH required for the neutralization of the active samples and the controls, the pulp and fermented seed extracts contain a proteolytic enzyme which reacts with peptone. It appears to be absent in the seed extract.

TABLE VI.—*Tests for inulase.*

SERIES 1.

	Test for glucose.
11 cc. water, 10 cc. pulp extract, 70 hours at 38° C	++
10 cc. water, 10 cc. pulp extract, 1 cc. inulin solution, 70 hours at 38° C	++
10 cc. water, 10 cc. pulp extract heated, 1 cc. inulin solution, 70 hours at 38° C	++
20 cc. water, 1 cc. inulin solution, 70 hours at 38° C	—

SERIES 2.

11 cc. water, 10 cc. seed extract, 70 hours at 38° C	—
10 cc. water, 10 cc. seed extract, 1 cc. inulin solution, 70 hours at 38° C	—
10 cc. water, 10 cc. seed extract heated, 1 cc. inulin solution, 70 hours at 38° C	—

TABLE VI.—*Tests for inulase*—Continued.

SERIES 3.

	Test for glucose.
11 cc. water, 10 cc. fermented seed extract, 70 hours at 38° C	+
10 cc. water, 10 cc. fermented seed extract, 1 cc. inulin solution, 70 hours at 38° C	+
10 cc. water, 10 cc. fermented seed extract heated, 1 cc. inulin solution, 70 hours at 38° C	+

The inulin solution used was a 10 per cent solution in water.

The test for glucose carried out showed that no hydrolysis of inulin had taken place, thus proving the absence of inulase.

TABLE VII.—*Tests for reductase.*

SERIES 1.

	Color change.
10 cc. water, 10 cc. pulp extract, 1 cc. methylene blue solution, 24 hours at 38° C	++
10 cc. water, 10 cc. pulp extract heated, 1 cc. methylene blue solution, 24 hours at 38° C	++
20 cc. water, 1 cc. methylene blue solution, 24 hours at 38° C	—

SERIES 2.

10 cc. water, 10 cc. seed extract, 1 cc. methylene blue solution, 24 hours at 38° C	+++
10 cc. water, 10 cc. seed extract heated, 1 cc. methylene blue solution, 24 hours at 38° C	+++

SERIES 3.

10 cc. water, 10 cc. fermented seed extract, 1 cc. methylene blue solution, 24 hours at 38° C	+++
10 cc. water, 10 cc. fermented seed extract heated, 1 cc. methylene blue solution, 24 hours at 38° C	+++

The methylene blue solution was made by saturating 1 cubic centimeter of alcohol with methylene blue and diluting the resulting solution to 40 cubic centimeters with water. In each case the change in color for the control is the same as the change in the fresh sample, indicating that there is no reductase present.

TABLE VIII.—*Tests for oxidases.*

SERIES 1.

	Change in color noted at 38° C.			
	Initial.	End of—		
		½ hour.	4 hours.	24 hours.
20 cc. water, 1 cc. guaiacum tincture	—	—	—	—
10 cc. water, 10 cc. pulp extract, 1 cc. guaiacum tincture	+	++	+++	—
10 cc. water, 10 cc. pulp extract heated, 1 cc. guaiacum tincture	—	—	—	—

TABLE VIII.—*Tests for oxidases*—Continued.

SERIES 2.

	Change in color noted at 38° C.			
	Initial.	End of—		
		½ hour.	4 hours.	24 hours.
20 cc. water, 10 cc. seed extract, 1 cc. guaiacum tincture.	++	+++	++++	+
20 cc. water, 10 cc. seed extract heated, 1 cc. guaiacum tincture	—	—	—	—

SERIES 3.

20 cc. water, 10 cc. fermented seed extract, 1 cc. guaiacum tincture	+	++	++	+
20 cc. water, 10 cc. fermented seed extract heated, 1 cc. guaiacum tincture	—	—	—	—

The 20 per cent guaiacum tincture used here was made by grinding the gum in alcohol and allowing it to stand at room temperature for two days. At the end of this time the solution was filtered and used at once.

Oxidases exist in the fresh seed in large quantities, but are present in relatively large quantities in the pulp also, although considerably less than in the seed. They exist in comparatively small amounts in the fermented seed, as evidenced by the changes in color recorded above. When the seeds are ground in water, the solution very soon assumes a brown color, and a flocculent precipitate separates out. This mass is the tannin precipitated by the oxidases.

TABLE IX.—*Tests for diastase.*

SERIES 1.

	Test for—	
	Glucose.	Starch.
40 cc. water, 10 cc. pulp extract, 48 hours at 38° C	++	—
40 cc. starch solution, 10 cc. pulp extract, 48 hours at 38° C	++	++++
40 cc. starch solution, 10 cc. pulp extract heated, 48 hours at 38° C	++	++++
40 cc. starch solution, 10 cc. water, 48 hours at 38° C	—	++++

SERIES 2.

40 cc. water, 10 cc. seed extract, 48 hours at 38° C	—	—
40 cc. starch solution, 10 cc. seed extract, 48 hours at 38° C	—	++++
40 cc. starch solution, 10 cc. seed extract heated, 48 hours at 38° C	—	++++

TABLE IX.—*Tests for diastase*—Continued.

SERIES 3.

	Test for—	
	Glucose.	Starch.
40 cc. water, 10 cc. fermented seed extract, 70 hours at 38° C	—	—
40 cc. starch solution, 10 cc. fermented seed extract, 70 hours at 38° C	++++	+
40 cc. starch solution, 10 cc. fermented seed extract heated, 70 hours at 38° C	—	++++

A 1 per cent solution of soluble starch was used in the examination for diastase. Fehling solution was used in the test for glucose and a 1 per cent solution of iodine in the test for starch. The test for diastase was negative in the pulp extract and the seed extract, but in the fermented seed extract the active sample gave a heavy test (++++) for glucose, while the control gave only a fair test (++), proving that considerable starch had been hydrolyzed by a diastase present. I conclude that diastase is present in the fermenting seed only.

TABLE X.—*Tests for invertase.*

SERIES 1.

	Test for invert sugar.
15 cc. water, 10 cc. pulp extract, 48 hours at 38° C	++
10 cc. water, 10 cc. pulp extract, 5 cc. sugar solution, 48 hours at 38° C	++++
10 cc. water, 10 cc. pulp extract heated, 5 cc. sugar solution, 48 hours at 38° C	++
20 cc. water, 5 cc. sugar solution, 48 hours at 38° C	—

SERIES 2.

15 cc. water, 10 cc. seed extract, 48 hours at 38° C	—
10 cc. water, 10 cc. seed extract, 5 cc. sugar solution, 48 hours at 38° C	—
10 cc. water, 10 cc. seed extract heated, 5 cc. sugar solution, 48 hours at 38° C	—

SERIES 3.

	Ventzke scale.
	°
15 cc. water, 10 cc. fermented seed extract, 73 hours at 38° C	+ 0.0
10 cc. water, 10 cc. fermented seed extract, 5 cc. sugar solution, 73 hours at 38° C	+ 5.4
10 cc. water, 10 cc. fermented seed extract heated, 5 cc. sugar solution, 73 hours at 38° C	+ 6.5
20 cc. water, 5 cc. sugar solution, 73 hours at 38° C	+ 6.8

A 10 per cent cane-sugar solution was used for the detection of invertase.

The test for invertase was strongly positive in the pulp extract; a fair test resulted in the fermented seed extract, while a negative test was obtained in the seed extract.

TABLE XI.—*Tests for raffinase.*

SERIES 1.

	Ventzke scale.
	°
10 cc. water, 10 cc. pulp extract, 72 hours at 38° C	0.5
10 cc. raffinose solution, 10 cc. pulp extract, 72 hours at 38° C	5.6
10 cc. raffinose solution, 10 cc. pulp extract heated, 72 hours at 38° C	11.0
10 cc. raffinose solution, 10 cc. water, 72 hours at 38° C	11.0

SERIES 2.

10 cc. water, 10 cc. seed extract, 72 hours at 38° C	0.0
10 cc. raffinose solution, 10 cc. seed extract, 72 hours at 38° C	+10.9
10 cc. raffinose solution, 10 cc. seed extract heated, 72 hours at 38° C	11.5

SERIES 3.

10 cc. water, 10 cc. fermented seed extract, 74 hours at 38° C	0.0
10 cc. raffinose solution, 10 cc. fermented seed extract, 74 hours at 38° C	9.8
10 cc. raffinose solution, 10 cc. fermented seed extract heated, 74 hours at 38° C	11.3

A 5 per cent solution of raffinose was used in this experiment. Any hydrolysis of the raffinose by raffinase would decrease the polariscope reading. There is a considerable decrease of the reading for the fresh pulp extract from the reading of the controls used and a slight difference in the reading of the analogous solution in series 2 and 3, indicating the presence of considerable activity of the raffinase in series 1 and less activity in series 2 and 3; or, the pulp contains a raffinase in considerable quantities, the fermented seed in somewhat less quantities, while the fresh seed shows scarcely any activity toward raffinose.

TABLE XII.—*Tests for maltase.*

SERIES 1.

	Ventzke scale.
	°
10 cc. water, 10 cc. pulp extract, 72 hours at 38° C	+0.5
10 cc. maltose solution, 10 cc. pulp extract, 72 hours at 38° C	+23.4
10 cc. maltose solution, 10 cc. pulp extract heated, 72 hours at 38° C	+23.7
10 cc. maltose solution, 10 cc. water, 72 hours at 38° C	+23.4

TABLE XII.—*Tests for maltase*—Continued.

SERIES 2.

	Ventzke scale.
10 cc. water, 10 cc. seed extract, 72 hours at 38° C	0.0
10 cc. maltose solution, 10 cc. seed extract, 72 hours at 38° C	+23.5
10 cc. maltose solution, 10 cc. seed extract heated, 72 hours at 38° C	+24.0

SERIES 3.

10 cc. water, 10 cc. fermented seed extract, 72 hours at 38° C	0.0
10 cc. maltose solution, 10 cc. fermented seed extract, 72 hours at 38° C	+23.2
10 cc. maltose solution, 10 cc. fermented seed extract heated, 72 hours at 38° C	+23.4

The maltose solution was a 10 per cent solution. Euler[13] makes the statement—

> In both the animal and vegetable kingdoms maltose almost always accompanies the diastases, from which it cannot often be separated.

However, not even the fermented seed extract which showed diastatic activity shows any maltase activity. This appears to be one of the rarer cases of diastases unaccompanied by maltase.

SUMMARY

The pulp surrounding the cacao bean contains a greater number of enzymes than the fresh bean itself. The pulp shows activity for the enzymes casease, protease, oxidase, raffinase, and invertase.

The fresh bean gave reactions for casease and raffinase, and very strong reactions for oxidase.

The fermented bean reacted for casease, protease, oxidase, diastase, raffinase, and invertase. The fermented bean shows the presence of protease and invertase, both of which are absent in the fresh bean, but present in the pulp. These must have penetrated the membrane surrounding the bean during fermentation. Diastase is present, but absent in the extracts from the fresh bean and from the surrounding pulp. This has been developed in the bean itself during the process of fermentation.

Therefore the conclusion is reached that the presence of these enzymes undoubtedly influences the character of the fermentation and that temperature control during fermentation is necessary in order that they may not be destroyed.

This cacao was furnished me by Mr. Jacobson, of the Bureau of Agriculture, Manila, to whom I wish to express my thanks.

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[13] General Chemistry of the Enzymes (1912), 19.

WATER SUPPLIES IN THE PHILIPPINE ISLANDS: II[1]

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PRESENT STATUS OF THE WORK ON PHILIPPINE WATER SUPPLIES

In spite of great progress made since the American occupation in the matter of providing the people of the Philippines with pure drinking water, the present state of affairs is still far from satisfactory. Whole provinces continue to be dependent on surface waters of doubtful purity, and even in many localities where safe water is obtainable, a large number of people, through ignorance or indifference, utilize more conveniently located and less wholesome sources. In addition, there are certain areas in which both surface and ground waters are not potable, where the people are forced to depend almost entirely on rain water for drinking purposes. As the rain water is often carelessly collected and improperly stored, it is hardly to be considered a safe water supply.

However, a marked movement at the present time for better conditions is evident both in the development of new sources of good water and in the gradual elimination of dangerous water supplies. The Insular Government has greatly stimulated the drilling of deep wells by continuing to assume the entire cost of unsuccessful public wells and two thirds of the cost of all successful installations, and has made large sums of money available for water-supply projects. Such progress has been made that it is estimated[2] that deep-well water is now available to over one sixth of the entire population of the Islands.

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[1] Received for publication April 15, 1915.

[2] Vickers, *Quar. Bull. P. I. Bur. Pub. Works* (1914), 2, 28.

During the year 1914 the Bureau of Public Works alone drilled 120 deep wells, 103 of which were successful, while provinces and private individuals drilled perhaps an equal number. The total number of deep wells in the Islands is over 1,000.

The progress of the movement for better water supply may be judged from the fact that over 50 water-distribution systems are already in operation, and that many municipalities, some of them very small, are planning to install systems in the near future. Two recently completed installations—at Boac, Marinduque, and Sariaya, Tayabas—are typical of what can be done in small towns. The former supplies from 3,000 to 4,000 people and derives its water from two deep-pumping wells; the latter supplies about 4,000 people and takes its water from a large spring on Mount Banahao, 6 kilometers from the town. The largest single project being developed at present is that of Iloilo, to which reference has already been made,[3] where an installation capable of supplying 55,000 people is being planned.

LABORATORY WORK

The Bureau of Science passes judgment on all newly developed public water supplies before they are made available to the public, and as there is no water laboratory outside of Manila, this central laboratory has been receiving a steady influx of water samples from all parts of the Islands. During the year 1914 about 200 chemical analyses and 2,100 biological examinations were made.

As many of these samples are not properly taken, are accompanied by insufficient data concerning the sources from which they come to justify conclusions concerning their potability, and are very old when they reach the laboratory, owing to the poor transportation facilities in some parts of the Islands, their sanitary analysis is of doubtful value. Under such conditions the judgment of water, not an easy task at best, often becomes impossible, especially as the insufficiency of the work done on Philippine waters and the diversity in quality of waters to be found even in restricted areas have made it impossible to establish fixed standards.

It is being generally recognized[4] that single "sanitary analyses" of waters are often of little value, especially when the analyst does not take the sample. The failure of the "conventional grind of nitrogen determinations" is amply demonstrated by the analytical records of the Bureau of Science, where waters known to be uncontaminated range as high as 20 or more parts per million in free ammonia content. Therefore it seems desirable to eliminate nitrogen determinations in most cases and to limit our efforts to the determination of normal mineral constituents, supplemented by biological examinations whenever feasible, until such time as our increased knowledge of Philippine waters and of tropical conditions shall justify other methods.

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[3] *This Journal, Sec. A* (1915), 10, 65.

[4] Cf. Barnard, *Eng. Rec.* (1913), 68, 297.

The analytical data obtained in the Bureau of Science laboratory during 1914 are contained in Tables III to V at the end of this paper. All results are given in terms of parts per million unless otherwise stated.

FIELD WORK

It soon became evident that a field survey offered the best solution of the problem of obtaining the most information concerning Philippine water supplies with the least possible expenditure of time and money. Accordingly a simple chemical field outfit, based on that described by Leighton,[5] was constructed. Field methods leave something to be desired, so far as accuracy is concerned, but it is thought that they have been more than justified by the volume of reasonably accurate work done in a comparatively short time, and by the intimate knowledge of local conditions made possible by the field trips.

In addition to the chemical equipment, the field outfit included a small portable bacteriological kit, consisting of Petri dishes, a case of sterile pipettes, and tubes of litmus lactose agar and lactose bile agar. A plate culture on litmus lactose agar gave an approximate bacteria count and showed the presence or absence of acid-forming bacteria; a tube culture in lactose bile agar indicated the presence or absence of lactose-fermenting organisms. The uniformly high temperature encountered in most parts of the Islands enables fairly concordant results to be obtained without the use of an incubator. Pipettes were separately wrapped with gauze and carried in a tinned cylinder; hence it was easy to sterilize them even in the field. The Petri dishes were simply wrapped in paper, in packages of six, before being sterilized; they remained uncontaminated for weeks. Bacteria counts were generally made at the end of both twenty-four- and forty-eight-hour intervals.

The field investigations were, in the main, confined to three islands: namely, Mindoro, Cebu, and Panay. The analytical data are tabulated at the end of this paper: Table VI dealing with deep wells, Table VII with springs, and Table VIII with surface and miscellaneous supplies.

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[5] *U. S. Geol. Surv., Water Supply Paper* (1905), 151.

DEEP WELLS

The following extract from an article by Vickers[6] gives a good summary of the Philippine deep-well situation:

> The cost of a sufficient number of machines of the deep-well type was in excess of the funds available at that time [1906] and the Insular Government met this demand for new equipment by designing and constructing several small hand-power outfits, known as "jet rigs." It was soon demonstrated that these outfits, owing to their simple design, could be operated to advantage by native workmen in localities where it was not necessary to drill to depths greater than 200 to 300 feet, and where no rock or difficult strata had to be penetrated; * * *. The demand for this class of equipment increased until 1911, when 45 jet rigs had been constructed and equipped for operation and practically every province, wherein they could be successfully operated, had been supplied with from one to five outfits. It was found, however, that in many localities the deep-well or steam-power rigs were necessary for successful operation, and the demand for wells in these localities was so insistent and increased to such an extent that additional equipment of this class was added from time to time, until 25 deep-well machines had been purchased. Funds for the operation of both jet and deep-well rigs were provided entirely by Insular appropriations until 1910; at this time a coöperative policy was adopted whereby one-third of the cost of drilling was borne by the provinces or municipalities for which the work was done and two-thirds by the Insular Government. The deep-well rigs were operated by the Bureau of Public Works as before, while many of the jet rigs remained under the supervision of provincial officials. This policy proved to be satisfactory and is still being followed.
>
> A large number of the wells drilled in the Islands have a natural flow, some of them supplying enormous quantities of water, notably, the famous gusher at Bayambang, Pangasinan, which supplies 1,000,000 gallons daily. The water from the latter is distributed through two main supply pipe lines, one leading to the military post at Camp Gregg, and the other to the town of Bayambang. In many of the provinces it is necessary to drill wells ranging from 600 to 800 feet in depth in order to obtain good water. In the town of Wright, Samar, good water was not encountered until a depth of 1,025 feet was reached, when flowing water of excellent quality was tapped. This well is the deepest in the Islands which supplies good water. A number of wells have been drilled to greater depths, however, but in every case except the one mentioned above salt water was encountered below 1,000 feet. The deepest well ever drilled in the Islands was located on the trade school grounds at Iloilo, and was sunk to a depth of 2,285 feet without encountering fresh water. An interesting feature in connection with some of the wells is the effect the ocean tide has upon the fresh-water flow, one remarkable instance being the

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[6] *Quar. Bull. P. I. Bur. Pub. Works* (1914), 2, 26.

well at Bauan, Batangas, drilled to a depth of 298 feet, which flows 250 gallons per minute 18 inches above the ground surface at high tide, and 50 gallons per minute at low tide at the same elevation; in other words, the flow at high tide indicates an increase of 400 per cent over the flow at low tide, notwithstanding the fact that analyses of water samples collected at both high and low tide give identical results and show the water to be potable and free from salt-water contamination.

In many borings, especially near the coast, brackish water is encountered during the first 30 to 70 meters, even though fresh water may be found at low levels. In some rather exceptional cases, in which salt water was encountered at great depths, continued drilling developed a supply of fresh water. At Wright, Samar, salt water was found at 180 to 215 meters; this was cased off, and drilling was continued. At 312 meters fresh water was found under sufficient pressure to cause a flow, which, although slight even at ground level, did not cease entirely at 12 meters above the earth's surface.

The deep-well waters are so lacking in uniformity that generalizations regarding them are difficult, if not impossible, at the present time. Very frequently wells drilled within a few meters of each other may encounter entirely different strata, and the water from them may be markedly different. Two wells drilled on the Bureau of Science grounds within 75 meters of each other are very different, both in regard to the water-bearing strata from which their supplies are derived, and the quality and quantity of water encountered. Well 1 runs 725 parts per million total solids and 70 parts chlorine; well 2 runs 500 parts total solids and 12 parts chlorine. Three wells in Iloilo (at the Iloilo Electric Company's works), located within about 15 meters of each other and drilled to about the same depth, show similar irregularities, two being approximately similar but differing from the third.

The minimum temperature of deep wells drilled in the lowlands is about 28° C., but the temperature range is great.

The deep-well waters range in total solids content from about 120 (well 129, Nueva Caceres, Ambos Camarines) to 8,200 parts per million (Janiuay, Iloilo), and in chlorine content from 1.5 (San Jacinto and Binalonan, Pangasinan) to 4,471 (Janiuay, Iloilo).

The highest free ammonia content recorded is that of a well at Los Baños, Laguna, 70 meters deep, which showed 32.7 parts per million. The reason for this abnormal content is not apparent.

In general, the deep wells show a high degree of bacteriological purity. The flowing wells, so far as known, are all sterile or very nearly so, and deep-pumping wells seldom show any marked degree of bacterial pollution except where the equipment is defective or carelessly handled.

SURFACE WELLS

Ordinary surface wells still furnish a large share of the water utilized in the Philippines and constitute a great menace to public health and an obstacle to sanitation. Numerous causes contribute to make these wells dangerous in the extreme, among which may be mentioned the fact that most of them are uncovered and many are uncurbed; the general method of drawing water from them is with a rope and bucket; they are located in crowded barrios; clothes are washed at the well side, and there is a general neglect of sanitary precautions.

The status of the surface well is clearly demonstrated by the results of biological examinations made in the field, as illustrated by Table I.

TABLE I.—*Bacteriological field examinations of surface wells, 1914.*

No.	Province and town.	Bacteria.		
		Approximate number per cc.	Acid formers.	Gas formers.
37	Cebu, Balamban	([a])	+	+
17	Cebu, Cebu	2,000	+	+
25	do	4,000	+	+
26	do	4,000	+	+
27	do	725	+	+
38	do	1,300	+	+
39	do	5,000	([b])	+
40	do	60	—	—
41	do	2,000	+	+
42	do	([a])	([b])	+
132	Iloilo, Iloilo	1,500	([b])	....
133	do	2,000	([b])	....
131	Iloilo, Iloilo (Molo)	2,000	—	....
136	do	1,500	+	....
6	Mindoro, Pola	([a])	+	+
7	do	([a])	+	+

[a] Excessive.

[b] Few.

The data in Table I were obtained from wells examined in the course of the field trips. Fifteen of the sixteen sources listed gave unmistakable evidence of pollution on a single examination, while the sixteenth was so located that contamination at some time seemed a foregone conclusion. Admitting that the data on which to base conclusions are limited in quantity, the facts that the results obtained by single examinations were so uniform, and that the examinations were made during the dry season when contamination was least likely to occur, show how unsafe surface wells in the Philippines are. It would probably be conservative to say that the water from over 80 per cent of the wells is unfit to drink, and that very few of the wells are safe throughout the year.

Chemically their waters show no marked peculiarities, and they have not been studied sufficiently to justify generalizations. Their quality doubtless varies greatly during different seasons. The surface wells listed, with the exception of a few located so near the ocean that they were obviously contaminated by sea water, range in total solids content from 164 to 1,230 parts per million, and in chlorine content from 5.5 to 436 (average, about 150), while the highest free ammonia content noted is 0.64.

RIVERS AND FLOWING STREAMS

No systematic study of water courses has yet been attempted. Doubtless as manufacturing industries develop, the question of the quality of the water of streams will increase in importance, but at present comparatively little river water is used. A comparatively small amount is being used for boiler purposes, but aside from this, practically the only water whose quality becomes a matter of consideration is that of the rivers which serve as sources of municipal water supply, as at Manila and Cebu.

The stream waters analyzed, with the exception of tidal rivers and water courses known to be contaminated, ranged from 45 to about 550 parts per million in total solids and from 2 to 150 in chlorine, and showed a maximum free ammonia content of 0.125 part per million.

SPRINGS

The contribution to the study of spring waters during the past year has been meager. There is a marked tendency to utilize spring waters more than formerly, notably in small towns so situated that such waters can readily be conveyed to them. In Cebu Province, where springs are numerous, there are at least sixteen towns which developed projects involving the utilization of springs for municipal supply.

As the country develops, many springs will doubtless become popular as health resorts. At present only a few springs are much visited. The Insular Government has erected a bath at Sibul Springs, and this place, as well as Los Baños and Pagsanjan, has many patrons. The Los Baños water is carbonated, bottled, and sold.

Some of the springs are so saline that the recovery of salt from them is an easy and profitable undertaking. A number of springs in Nueva Vizcaya are now so utilized.

The waters vary widely in quality. The total solids content ranges from 24 to 6,025, and chlorine from 0.7 to 3,120, while the maximum free ammonia content is 6.2.

WATER SUPPLIES OF MINDORO

Mindoro, one of the largest of the islands of the Archipelago, is very sparsely populated. It has between 60,000 and 70,000 inhabitants, who live near the coast. The interior has been little explored and is uninhabited except for from 6,000 to 7,000 uncivilized Mangyans.

The surface waters in many districts, in addition to being unsafe, are so brackish that they are unpleasant to the taste, and a great deal of trouble has been experienced in providing the people of Mindoro with water. However, in recent years the water supply has been greatly improved by the installation of jet-rig wells by the provincial authorities.

A brief field trip was made to Mindoro for the purpose of investigating the proposed municipal water supply of Calapan, the provincial capital, but the scope of the investigation was later enlarged to include several other towns.

Calapan.—Calapan, a town of 9,000 inhabitants, is extremely unfortunate in regard to water supply. The surface wells are brackish, the river is affected by the tides, and good springs are lacking. All attempts to secure a supply of potable water by sinking deep wells have been without success. Limited amounts of brackish water are found at slight depths in drilling operations. Black sand containing sea shells is found underlying the soft coralline formation near the surface, until, at a depth of about 30 meters, a hard rock stratum about 30 centimeters thick is encountered. Penetrating this rock the drill suddenly sinks, and very hot, salty water rises in the drill hole to about ground level. The water from the well at the public market at Calapan showed a temperature of 40° C. Although clear and colorless at first, it became yellow and turbid on standing for a short time, due to the escape of carbon dioxide and the resulting precipitation of calcium and iron salts.

A large spring about 4 kilometers from Calapan, having an estimated flow of 55 liters per minute throughout the dry season, has been proposed as a source for the town supply. Although the water is potable, the spring is so located that there might be difficulty in guarding it from future contamination, and its elevation is so slight that a pump would probably have to be installed to make the water available for municipal supply.

There were formerly a number of sulphur springs at Calapan which were used as baths. At the time of examination the place pointed out as the site of the springs was a small swamp, which contained a few small springs of clear saline water having no odor of hydrogen sulphide. The temperature of the water was 50° C.

Naujan.—Naujan, which has a population of 7,000, has been supplied with water through the efforts of the provincial authorities. Four flowing wells have been drilled, which give abundant quantities of excellent water; two of these wells are cased with 3-inch pipe and two with 2-inch pipe. Unfortunately some local prejudice seems to persist against their use, and the populace as a whole still depends in a large measure on surface supplies and on rain water; the latter, owing to improper methods of collection and the custom of storing it in large uncovered earthenware jars, is of questionable purity.

The artesian waters, it is claimed, have the odor of hydrogen sulphide at some seasons of the year, which may account for their lack of popularity.

Pola.—Pola is a town of less than 3,000 inhabitants, depending for its water supply on open dug wells or shallow bored or "punched" wells. The supply is very unsatisfactory, as it is somewhat brackish and for the most part subject to contamination at all times. All the wells examined biologically gave evidence of sewage pollution. Tiguihan River, a mountain stream located a short distance from the town, promises to be a satisfactory source of water. It drains an apparently uninhabited area, has a volume large enough to insure an adequate supply, and appears to have sufficient elevation to enable the installation of a direct-gravity system. The water has an excellent local reputation and seems to be entirely suitable for domestic purposes.

Pinamalayan.—Pinamalayan has a population of over 6,000, and is greatly in need of a municipal water supply, as the surface wells are all brackish and unsafe. The attempt to secure deep wells has been unsuccessful, as only salt water was encountered in any quantity, although drilling was continued to a depth of about 75 meters, the approximate limit of the well-drilling outfit used. The geologic formation is estuarine and littoral, consisting of clay, sand, and shells with intercalated layers of sandy coral. Logs with the bark still adhering were encountered at a depth of 65 meters.

There is a small stream about 2.5 kilometers from the town which might be utilized for municipal supply if properly guarded from contamination; at any rate, the chemical character of the water and the location of the stream present no obstacles to the development of the project.

A short distance from the old town of Pinamalayan, and farther inland, a new town site is being developed. Four wells were recently drilled here. A good flow of water was obtained at a depth of about 50 meters. The water is of good quality and should prove suitable for most purposes.

WATER SUPPLIES OF CEBU

Good progress has been made in supplying Cebu Province with potable water. The city of Cebu has recently completed a reservoir and water-distribution system which is one of the finest municipal waterworks in the Philippines. Excellent springs are abundant and are much used in spite of the fact that many of these are so located that they are not available to very many people. At the present time nearly twenty towns have well-developed projects for utilizing springs, as shown by Table II, the data in which were supplied (November, 1914) by the provincial district engineer's office. The money necessary for some of these projects has already been appropriated.

TABLE II.—*Data for proposed water supplies, Cebu Province, 1914.*

Municipality.	Name of spring.	Population to be supplied.	Flow per minute.	Per capita supply.	Pipe line.	Elevation above town.
			Liters.	*Liters.*	*Meters.*	*Meters.*
Argao	Kabagohan	5,000	75	25	3,600	110.00
Barili	Mantayapan	5,000	1,900	75	4,450	131.68
Carcar	Guadalupe	5,000	100	30	3,100	18.00
Catmon		1,500	95	90	1,700	42.00
Ginatilan		2,000	40	55	2,320	201.40
Malabuyoc		1,300	275	55	1,340	9.42
Moalbual		2,000	1,900	75	4,040	32.61
Naga	Jugan	1,981	55	65	1,430	77.00
Pilar		1,000	35	105	2,314	58.25
Poro	Cantaway	1,000	55		1,820	138.49
Samboan	Din-ak	2,000	480		1,226	30.09
Sibonga	Balaas	5,000	195	40	4,703	105.00
Tudela	Guinawitan	1,000	65		1,640	95.13

At least one additional town, Asturias, has since started a similar town project.

Attention has already been directed [7] to a special study of typical springs made by Mr. V. Q. Gana in 1908.

A rather peculiar spring is situated in the city of Cebu on the beach near the old leper house. The water from this spring—or, more properly, series of springs—is fresh as it issues from the sands of the seashore, although the springs are entirely covered at high tide. Abella mentions [8] a spring situated on the beach at Oslob, which is submerged at high tide, so that people are obliged to wade out into the ocean to collect the water. At low tide the flow is greatly decreased.

Approximately thirty successful deep wells have been drilled in Cebu Province by the Bureau of Public Works alone; however, about one half of these are located in the city of Cebu. Strangely enough, although the Province of Cebu is mountainous, only one flowing well (at Argao) has been developed, and this flows only at high tide. The installation of deep wells has done much toward improving local health conditions.

Although unsafe surface waters still constitute a large percentage of the available water supply, an active campaign against surface wells inaugurated by the district health officer is rapidly lessening the evils which may be traced to the use of impure water.

The field trip in Cebu included one journey south from Cebu to Argao and another from Cebu west to Toledo and north from Toledo to Asturias.

City of Cebu.—The main source of water supply for the city of Cebu is now the Osmeña Waterworks, completed in 1912. This installation, in addition to the distributing system in the city and a concrete distribution tank, comprises a reënforced-concrete dam and spillway located in a narrow gorge at Buhisan, about 6 kilometers from the town. Between 1,000,000 and 1,500,000 cubic meters of water are impounded by the dam, representing a supply, based on the water-consumption data for Manila, of at least one hundred days for the city of Cebu (population, 60,000). The water is clear to begin with at almost all times of the year, and the great storage capacity of the reservoir, supplemented by that of the distribution tank (over 15,000 cubic meters—that is, almost two days' supply), gives ample opportunity for sedimentation and purification. The elevation of the distribution tank is such that the water pressure in the Cebu city mains is about 7 atmospheres.

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[7] *This Journal, Sec. A* (1914), 9, 273.

[8] Rapida Descripcion . . . de la Isla de Cebu. Madrid (1886), 87.

The water is neither filtered nor chemically treated at present, and it does not appear likely that it will need treatment, at least for some time to come. As it now leaves the taps in the city, it is clear and colorless and very low in bacterial life. It is high in iron, which may lead to the growth of *Crenothrix* later on, but so far no trouble from that source has been experienced.

The deep wells in the city of Cebu, about fifteen in number, are from 25 to 36 meters deep, at which depth abundant supplies of good water are encountered. In no case under observation did the wells of this type show signs of sewage contamination. The strata encountered in well-drilling are alluvium overlying coral, none of the successful wells, so far as known, having penetrated the latter. There is one artesian well on Cauit Island, near Cebu, which is 90 meters deep and flows only at high tide. Its salt content has almost doubled since 1906, when the well was installed.

After the installation of the municipal water system, the health authorities started a vigorous campaign against surface wells, with the result that the majority have already been closed and the others will shortly be filled up and abandoned. Considerable local opposition to the action of the authorities was developed, as people naturally object to the destruction of wells, which represent considerable investment, and whose purity they have never learned to question. Among some classes of people there was even a marked antipathy to the use of the city water. However, that the campaign was necessary was clearly demonstrated by the district health officer, who traced the relationship between the spread of cholera and the use of well water, showing, among other things, that excessive rainfall, and consequent pollution of the surface wells, produced an increase in the number of cholera cases in times of epidemic. As public hydrants have been placed in those parts of the city where the people are too poor to pay for the water installations, and as no wells were ordered closed until the city water supply was made available, no real hardship has been imposed on any one. The marked improvement in local health conditions has more than justified the efforts of the health officials.

Although there could be little question of the status of wells in general, it had been hard to get definite and conclusive evidence against suspicious sources, and people had resented having wells closed for no better reason (to them) than an arbitrary order from the authorities. There was no laboratory available for water examination and no persons to do such work, so the arrival of our small portable outfit proved of assistance to the local health authorities. The character of the wells may be inferred from the fact that although the investigation was conducted during the dry season the wells, almost without exception, showed evidence of pollution on a single examination.

The west coast of Cebu.—For the most part the inhabitants of the west coast of Cebu are still dependent for their drinking water on rain-water cisterns and on surface wells, many of them brackish. There are a number of excellent springs, but many of them are not conveniently located and have not yet been developed, and many are not cared for at all or are so poorly safeguarded that their water supply is not above suspicion. Doubtless many towns could install small municipal water systems at moderate cost, deriving their supply from springs in the vicinity.

The attempt to improve the water supply by means of deep wells has not met with unqualified success. At Barili and Moalbual drilling was continued to 225 and 300 meters, respectively, but only salt water was encountered. At Toledo the experience has been more fortunate. Boring has been continued to 55 meters, and potable water, under sufficient pressure to rise within 3 meters of ground level, has been developed. However, one of the Toledo wells turned brackish within the last six months.

The towns of Asturias and Balamban are dependent in a great measure on surface supplies and rain water, although there are excellent springs in the vicinity which could be developed for municipal supply.

The east coast of Cebu.—In addition to Cebu itself, the towns visited in the course of the trip along the east coast of Cebu were Talisay, Minglanilla, Naga, Carcar, Sibonga, and Argao. All of these, except Carcar and Argao, are almost entirely dependent on rain water and surface supplies. In Minglanilla, it is true, there is a large spring, which, although unfortunately located with respect to surface drainage and showing a suspiciously high bacteria count, probably yields the best water available in that district. The Argao well furnishes good potable water from a depth of 150 meters, but unfortunately only comparatively few of the town people use it exclusively. There are two deep wells in Carcar, one owned by the railroad, the other by private individuals, both of which furnish water which is chemically satisfactory.

WATER SUPPLIES OF PANAY

Iloilo.—The general features of the water supply situation of Iloilo have already been referred to,[9] so that only some of the more significant details need be discussed here. The water supply problem of Iloilo Province presents the characteristics and difficulties encountered in other parts of the Archipelago, with the added complication that, so far, no really good artesian supply has been developed. In the city of Iloilo the problem has always been exceedingly perplexing, because the surface wells are all brackish, and except for rain water all natural waters used for drinking purposes have to be carried for considerable distances.

Many deep wells have been drilled, most of them in the city of Iloilo, with rather interesting results. Those in Iloilo, the majority of them flowing wells, are between 80 and 90 meters deep, no good water having been found at greater depths in this locality. The deepest well on Panay is at Janiuay. It is a flowing well 375 meters deep, which yields an intensely salty water. The deepest well whose water might be considered potable is about 165 meters deep, located at Santa Barbara.

Chemically the artesian-well waters show marked peculiarities. They are all brown, charged with gas, and as already pointed out,[10] have an abnormally high free ammonia content. All of them are brackish,[11] the well at Santa Barbara showing the lowest chlorine content (240 parts per million). A marked peculiarity is the absence of sulphates. Most of the waters are very hard and high in mineral salts, so it is interesting to note that the Santa Barbara well, with a total solids content of over 1,000 parts per million, contains no calcium, and that the Mandurriao and Molo wells are very low in calcium content.

With the present unsatisfactory character of the deep-well waters it seems probable that rivers and springs will have to be utilized to a much greater extent than they are now, and that greater care will have to be exercised in safeguarding available sources.

Although rain water, often improperly collected and carelessly stored, is hardly a source above suspicion for domestic purposes, it has occasionally been made an excellent water supply, notably in the city of Iloilo, where a number of properly constructed cisterns are giving good results.

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[9] *This Journal, Sec. A* (1915), **10**, 65.

[10] Ibid. (1914), **9**, 339.

[11] It is interesting to note that in Iloilo many people, among them Americans and Europeans, have accustomed themselves to drinking the deep-well water (total solids content, 2,000±; and chlorine content, 800–900) without experiencing any noticeable ill effects.

At Capiz, where the surface supplies are uniformly bad and well drilling has resulted in failure, the construction of a cistern large enough to supply the residents of the city with drinking water is being contemplated.

WATER SUPPLIES OF MANILA

The problem of adequately supplying the city of Manila with water is still troublesome, and funds for making improvements are not available. It appears to be extremely difficult to impound sufficient water at Montalban to last throughout the year, due in a great measure at least to leakage, which the decomposed and water-worn character of the limestone formations at the site of the dam makes unavoidable. For the last two years it has been necessary to supplement the Montalban supply with water from Mariquina River, a proceeding which has proved a serious menace to public health. The total storage capacity is too small to allow of much sedimentation, and as no provision for filtration has been made, water which is still carrying varying amounts of suspended matter finds its way into the city mains. Large quantities of foreign substances are thus allowed to accumulate in the pipes, and the attempts to purify the water with chloride of lime are seriously interfered with. During the period in which chlorination has taken place, the water, as examined at various points in the distributing system, has shown, with increasing distance from the chlorination station, first a marked decrease in bacterial count and frequently the absence of amœbæ and colon-group bacteria in 2 cubic centimeters of samples of water, then a gradual rise in count, and the reappearance of the organisms mentioned. Day after day the bacteria count at the Bureau of Science tap has been in excess of that of the water at the reservoir, although, at intermediate points, the bacterial count has been exceedingly low. Frequent flushing out of the distributing system is undoubtedly of great benefit, but in itself is not enough to cause much improvement. In the absence of reservoirs large enough to ensure adequate sedimentation, a rapid sand filter, with proper equipment for previous coagulation whenever the water is turbid, is an imperative present necessity.

TABLE III.—*Analyses of water from deep wells, 1914.*

[P = pumps; F = flows.]

Tracing No.	Laboratory No.	Well No.	Location.	Depth.	Month.	Diameter.	Water-bearing materials.	Capacity per minute.	Height of water above (+) or below (—) surface.	Depth of casing.	Physical characteristics.
				Meters.		*Inches.*		*Liters.*	*Meters.*	*Meters.*	
1	118767		Agusan, Cabadbaran								
2	119182		do								Normal.
3	119419	680	Albay, Bato (barrio Cabugao)	50	October		Gravel, tuff, andesite	P 50		43	Slight sediment.
4	118261	601	Albay, Tabaco	123	February		Volcanic fragments and tuff.	F 57		122	Brown.
5	118685	601	do	123	May		Same as No. 3	F 57		122	
6	118656	615	Albay, Virac	351	do		Limestone and fine limestone sand.	P 23		266	
7	118814	648	do	61	do		Limestone	P 68	— 4.5	60	
8	119202	657	do	267	August		do	P 60		236	Normal.
9	119112	443	Ambos Camarines, San Jose No. 2.	36.6				P 68			Very turbid.
10	118046	584	Batangas, Batangas	163	December		Tuff, clay, sand	P 151		146	Turbid.
11	119051	670	Batangas, Batangas (Calle Jaena).	97	July		Tuff	P 378		74	Normal.
12	119111	673	Batangas, Batangas (Government building).	89	August	6	Sand	P 378		78	Do.
13	119211	681	Batangas, Batangas	140	September	6	Sandstones	P 378		128	Do.
14	119293	686	Batangas, Batangas (Calle P. Burgos.	145	do	6	Sand	P 189		136	Slightly turbid.
15	119420	690	Batangas, Batangas	142	October	6	do	P 113	— 3.7	128	Normal.
16	119581	697	do	130	December	6	Brown sand rock	P 132	—27	116	Do.
17	118864	638	Batangas, Bauan (barrio Asias)	117	June		Tuff	P 132		46	
18	119002	638	do	117	July		do	P 132		46	
19	119134	638	do	117	August		do	P 132		46	Normal.

20	119073	640	Batangas, Bolbok	171	July	4.5	Limestone with tiny shells	F 18		143	Yellow brown.
21	119255	672	do	189	September		Tuff, gravel, limestone fragments.	F 56	+7.5	139	Normal.
22	119564	688	Batangas, Bolbok (barrio Sico)	184	December	4.5	Sand and gravel	F 75		180	Colored and slightly turbid.
23	118223	577	Bohol, Inabanga	136	January	4.5	do	P 37		130	Yellow.
24	118408	192	Bohol, Tagbilaran	207	March		Sand	P 227			
25	118556	619	do	39	April	8	Coral rock	P 378		28	Odor of H_2S; some sediment.
26	118110		Bulacan, Marilao								
27	118047	586	Bulacan, Baliwag, Camboag	172	January		Clay, gravel, etc	F 113		157	Normal.
28	118305	603	Bulacan, Baliwag, Tanauan	137	February	4.5	Clay, sedimentary gravel	F 75		136	Do.
29	118596	616	Bulacan, Baliwag, Sabang	137	April		Clay, gravel, tuff	F 227		134	
30	118228		Bataan, Pilar (Calle Kansas)		February						Normal.
31	118228		Bataan, Pilar (Calle S. Jose)		do						Do.
32	118228		Bataan, Pilar (Calle S. Pedro)		do						Do.
33	118228		Bataan, Bataan Pequeño (Calle S. Jose).		do						Do.
34	118228		Bataan, Santa Rosa (Calle Mabolo).		do						Do.
35	118228		Bataan, Santa Rosa (Calle Masantol).		do						Do.
36	119601		Bataan, Calle Pañganiban, Orion.		December						Do.
37	119601		Bataan, Calle Real, Orion		do						Do.
38	119601		Bataan, Calle P. Gomez, Orion		do						Do.
39	119601		Bataan, Calle P. Gomez, Orion		do						Do.
40	118593	2	Butuan		April						
41	119053	659	Cavite, Talipapa, Imus	151	July		Tuff, sand, clay	F 378		135	Normal.
42	119172	678	Cavite, Imus	91	August	4.5	Sand, tuff	F 56; P 568	−1	77	Do.
43	119505	684	do	267	November	4.5	Tuff etc	P 75	−21	251	Normal; slight sediment.
44	118366	611	Cavite, Santa Isabel, Kawit	119	March		do	F 60; P 302			
45	118686	631	Cavite, Kawit	122	May		Tuff and sand	F 22; P 378		95	
46	118813	646	Cavite, Binacayan, Kawit	142	June		Clay, sand, tuff	F 34; P 227		125	Normal.

TABLE III.—*Analyses of water from deep wells, 1914*—Continued.

Tracing No.	Laboratory No.	Well No.	Location.	Depth.	Month.	Diameter.	Water-bearing materials.	Capacity per minute.	Height of water above (+) or below (—) surface.	Depth of casing.	Physical characteristics.
				Meters.		*Inches.*		*Liters.*	*Meters.*	*Meters.*	
47	118166	599	Cavite, Noveleta	105	January	4.5	Tuff, clay, sand	F 45		93	Do.
48	118262	604	Cavite, San Juan, Noveleta	106	February	6	Tuff	F 94; P 378		97	
49	118555	617	Cavite, San Jose, Noveleta	103	April		Tuff and sand	F 11; P 227		34	
50	118661	146	Capiz, Capiz	306	May		Shale	P 75	—21		
51	119411	374-A	Cagayan, Tuguegarao	390	November			P 113			Turbid.
52	118277		Cebu, Bagumbayan, Cebu	20	February						Normal.
53	119237	682	Cebu, Toledo	15	September	6		P 264	—18	13	Slightly brown.
54	119323	689	do	54	do	8	Black sand containing shells.	P 60	— 8	42	Slightly turbid.
55	118167	600	Iloilo, Iloilo	80	January			F 45		80	Yellow brown.
56	118057	597	do	80	December						Brown.
57	119138	112	Iloilo, Sta. Barbara	157	August	6	Sand	F 151		80	Brown; slight sediment.
58	118119	587	Laguna, Famy	117	January	8	Gravel	F 68	+ 2	114	Normal.
59	119055	671	Laguna, Mabitac	99	July		Clay, tuff	F 113; P 265		93	Do.
60	119196	674	Laguna, Santa Maria	145	September		Clay fragment, limestone	F 64	+ 3.5	137	Do.
61	119382	685	Laguna, Pagsanjan	91	October		Clay, tuff, etc	F 605		90	
62	118409	576	La Union, Bangar	143	March		Sand, gravel, plutonic, volcanic.	P 246	— 1	231	
63	119050	623	La Union, Balaoan	266	July		Clay, limestone, shale (?)	P 37		269	Brown; much sediment.
64	119256	623	do	266	September		do	P 37		269	Do.
65	119326		Manila, 1338 Calle Juan Luna		October						Normal.
66	118752		Manila, Escolastica's College		May						
67	118904		Manila, Philippine General Hospital.		June						
68	118904		do		do						

69	118676		Manila, Division of Cold Storage, Bureau of Supply.		May						
70	118826		do		June						
71	119034		do		July						Do.
72	119348		do		October						Do.
73	119426		do		November						Do.
74	119544		do		December						Do.
75	119615		do		do						Do.
76	118013 118128		Manila, Calle Principe (Yangco Steamship Co.).		January						Do.
77	119407	410	Misamis, Cagayan		November						Turbid.
78	118644	484	do	169	May		Gravel and pumice	P 227		167	
79	118958	613	Nueva Ecija, Aliaga	153	July		Tuff, clay, gravel	F 41	+ 4.5	142	
80	119074	662	Nueva Ecija, Cuyapo	132	do		Clay, sand	F 94		132	Normal.
81	119257	677	do	111	September	4.5	Sand	F 151	+ 0.86	111	Do.
82	119595	687	do	170	December	4.5	Sand and gravel	F 7; P 151		170	Do.
83	119531	691	Nueva Ecija, Cabanatuan	186	do	4.5	Gravel	F 45		185	Do.
84	118094	538	Occidental Negros, Murcia	318	do	4.5	Fine volcanic sand	P 94		209	Turbid, yellow.
85	119036	594	Occidental Negros, San Carlos	247	July					245	Normal.
86	119185	594	do	247	September	6	Sand and gravel	P 113	— 6.1	245	Brown.
87	118529	597	Occidental Negros, Bacolod	161	March		Tuff	P 151		164	
88	118597	629	do	35	April		Tuff	P 75		33	
89	118654	633	do	44	do			P 265		44	
90	118687	634	do	36	May		Tuff and sand	P 75		37	
91	118905	635	do	38	June	4.5	do	P 113		30	
92	118906	650	Occidental Negros, Bacolod (Lacon and Rizal).	30	do		Volcanic sand, tuff	P 75		28	
93	118907	653	Occidental Negros, Bacolod (barrio Magdalena).	36	do		do	P 75		27	
94	119186	653	do	36	September		do	P 75		27	Normal.
95	119187	661	Occidental Negros, Bacolod	59	August		Sand	P 56	— 3.3	58	Yellow, turbid.
96	119188	664	Occidental Negros, Sumog, Bacolod.	100	do	4.5	Sand ?	P 94		84	Normal.
97	118410	588	Oriental Negros, Dumaguete	136	March		Sand, diorite, and andesite.	F 151		141	

TABLE III.—*Analyses of water from deep wells, 1914*—Continued.

Tracing No.	Laboratory No.	Well No.	Location.	Depth.	Month.	Diameter.	Water-bearing materials.	Capacity per minute.	Height of water above (+) or below (—) surface.	Depth of casing.	Physical characteristics.
				Meters.		*Inches.*		*Liters.*	*Meters.*	*Meters.*	
98	118478	620	Oriental Negros, Dumaguete (Silliman Institute).	13	do		Sand, andesite	F 1135		7	
99	118820	621	Oriental Negros, Bacong	150	June		Pumiceous sand and gravel.	P 264		149	Red sediment.
100	119102	621	do	150	August		do	P 94		149	Normal.
101	119090	654	Oriental Negros, Dauin	68	July		Andesite, coral, and tuff	P 75		65	Turbid.
102	119409	676	Oriental Negros, Zamboanguita.	42			Andesite	P 302		42	Normal.
103	119337		Pampanga, Lubao		October						Yellow.
104	118044	535	Pangasinan, Asingan	171	December			P 378		93	Normal.
105	118045	558	Pangasinan, Rosales	182	do	4.5	Gravel ?	P 378	—27.4	107	Do.
106	118950	602	do	221	June	4.5	Gravel	P 227		220	
107	119079	602	do	221	August						Do.
108	118174	598	Pangasinan, Urdaneta	79	January	8	Sand and gravel	F 94		77	
109	118300	605	do	85	February	4.5	do	F 56		84	Do.
110	118411	614	Pangasinan, Mabini, Urdaneta.	73	March	6	do	F 340		71	
111	118617	630	Pangasinan, Villasis	34	April	8		F 75		31	
112	118746	637	do	42	May		Clay sand, volcanic	F 265		40	
113	118812	642	Pangasinan, Villasis (barrio San Blas).	31	June	6	Sand	F 189		30	
114	118895	645	Pangasinan, Villasis	73	do	4.5	Sand and gravel	P 227		72	
115	119057	645	do	73				P 227		72	Do.
116	119437	655	Pangasinan, Balungao	229	November		Sand, clay, and tuff	P 37		229	Do.
117	118100	PB	Rizal, San Juan del Monte		January						Do.
118	118695	PB	do		May						

119	118696	PB	do		do						
120	118571	258	Rizal, San Pedro Macati	171	April		Tuff and clay	F 11; P 75		104	
121	119051	438	Rizal, Pasay	117	July	4.5	Sand	F 68		39	Do.
122	119113	520	Rizal, Jalajala	128	August		Tuff etc	P 75		119	Very turbid.
123	1190230	520	do	149	September		do	P 227	— 6.1	148	Brown.
124	119334	520	do	185	October		do	P 56		163	Turbid.
125	119573	701	do	39	December	6		P 113			Do.
126	119614	546	Rizal, Cardona	32	do		Clay, gravel, sand	P 113		20	
127	118141	595	Rizal, Navotas	189	January	6	Tuff, clay, sand	P 47		181	
128	118381	609	Rizal, Tangos, Navotas	198	March		Tuff etc	P 113		175	
129	118456	609	do	214	do		do	P 227			
130	118477	612	Rizal, Taytay	73	do		do	P 132		48	
131	118544	626	do	30	April		Sand, gravel, clay, tuff	P 132		15	
132	118610	632	do	41	do	6	Sand and gravel	P 75		26	
133	118707	639	do	33	May	6	Clay and gravel	P 132		26	
134	118666	627	Rizal, Malabon	143	do		Clay?	F 1.5; P 113		113	
135	118863	649	Rizal, Malabon (barrio Baritan).	148	June	6	Sand	P 113		143	
136	119028	665	Rizal, Malabon (barrio Tanyong).	88	July		Sandstone	P 113		82	
137	119122	675	Rizal, Malabon (barrio Tansuya).	104	August			P 113		92	Normal.
138	118055		Rizal, Caloocan		January						Do.
139	118499	105	do	217	April		Tuff and sand	F 75			
140	119335	683	do	205	October	4.5	Sand	F 4; P 75		204	Do.
141	119548	695	do	190	December		do	F 94		182	Do.
142	118476	491	Sorsogon, Bacon	174	March			P 113			
143	118526	593	Sorsogon, Juban	160	March	6	Igneous sand	P 45		159	
144	118992	618	do	149	July		Volcanic fragments	P 30		146	
145	119203	668	Sorsogon, Magallanes	122	September		Tuff, volcanic sands, and limestone.	P 113		122	Do.
146	119493	692	Sorsogon, Bulan	114	November		Tuff, with limestone at bottom.	F 19		106	Turbid.
147	119575	699	Zambales, Botolan	116	December			P 75	— 3	76	Do.

TABLE III.—*Analyses of water from deep wells, 1914*—Continued.

Tracing No.	Total solids.	Fixed solids.	Volatile solids.	Free ammonia.	Albuminoid ammonia.	Nitrates.	Nitrites.	Chlorine (Cl).	Carbonates (CO_3).	Bicarbonates (HCO_3).	Sulphates (SO_3).	Alkalinity ($CaCO_3$).	Silica (SiO_2).	Iron oxide and alumina ($Fe_2O_3+Al_2O_3$).	Iron (Fe).	Calcium (CaO).	Magnesium (MgO).	Total hardness ($CaCO_3$).	Analyst.
1	228			0.012	0.067	0.099	0.0	2.44			8.8		21.7	1.7		23.7	10.7		Natividad.
2	174	114	60	0.004	0.041	(d)	0.8	1.9			0.5		73.7	15.7		19.7	18.7		Do.
3	1,565.5							567.0	0.0	145.2	[a]43.5	119.0	30.0		(d)	[b]35.7	[c]6.3	107.9	Peña.
4	206			0.348	0.097	0.0	0.0	5.71			(d)		65.7	4.9		(d)	(d)		Gana and Natividad.
5	208			0.202	0.144	(d)	0.0	6.2			73.3		59.7	3.7		1.7	0.0		Natividad.
6	420			0.035	0.042	0.0	(d)	7.6											Do.
7	670			0.048	0.012	0.0	0.0	191.1			37.0		25.7	1.7		51.7	49.8		Do.
8	562	476	86	0.004	0.019	(d)	0.0	130.3			19.7		21.7	1.7		89.7	52.0		Do.
9	294	270	24	0.019	0.024	(d)	1.2	4.3			76.7		85.7	7.7		43.7	5.7		Do.
10	328.8			0.005	0.038	0.0	(d)	4.68			7.7		58.9	1.7		59.7	27.6		Gana.
11	380.0			0.007	0.0	(d)	(d)	10.3			6.1		73.7	3.7		49.7	28.9		Natividad.
12	390.0	340	50	0.021	0.009	0.0	0.0	9.2			9.5		77.7	3.7		39.7	30.3		Do.
13	355.7	287.6	68.1	0.0	(d)	0.63	(d)	11.5			6.0		67.7	3.7		55.7	23.1		Do.
14	376	314	62	0.0	0.0	0.0	(d)	9.9			6.0		67.7	(d)		21.3	24.5		Do.
15	370.0							6.3	0	189.7	[a]42.9	272	6.5		(d)	[b]42.9	[c]16.2	155.0	Peña.
16	362.5							7.2	0.0	278.7	[a]4.1	253	57.5		(d)	[b]48.3	[c]19.1	199.8	Do.
17	382			0.009	0.0	2.37	0.06	13.0			23.7		71.7	9.7		71.7	59.7		Natividad.
18	382			0.019	0.009	1.18	(d)	14.8			5.3		69.7	1.7		67.7	27.4		Do.
19	390	324	66	0.007	0.009	4.9	(d)	13.0			86.7		75.7	7.7		69.7	18.7		Do.
20	864			1.09	0.03	(d)	(d)	155.7			0.0		31.7	3.7		1.7	2.0		Do.
21	980	940	40	0.898	0.033	0.0	0.0	247.6			10.1		37.7	3.7		25.7	18.7		Do.
22	825.0							108.2	0.0	646.6	[a]0.0	551.0	32.5		2.5	[b]10.2	[c]0.0	26.8	Peña.
23	802.0			0.294	0.211	0.0	(d)	18.2			129.5		29.7	4.9		194.5	120.9		Gana and Natividad.
24	240			0.024	0.014	(d)	(d)	3.26			22.5		97.7	7.7		31.7	10.0		Do.
25	418			0.398	0.301	(d)	0.0	42.2			6.0		13.7	1.3		132.1	7.8		Natividad.

26	------	------	------	0.060	0.048	(d)	0.0	17.2	8.6	161.7	15.4	------	29.6	0.75	------	3.7	(d)	------	Gana.
27	583.6	------	------	0.137	0.063	0.0	0.0	278.3	------	------	11.4	------	18.1	3.3	------	17.3	(d)	------	Do.
28	968.0	------	------	0.280	0.068	0.0	0.0	542.4	------	------	4.0	------	17.72	7.7	------	29.7	1.4	------	Do.
29	1,089.6	------	------	0.38	0.06	0.0	0.0	584.8	------	------	107.6	------	17.7	1.7	------	45.7	0.6	------	Natividad.
30	295.6	------	------	0.361	0.140	0.0	(d)	10.8	------	------	------	------	------	------	------	------	------	------	Gana.
31	290.0	------	------	0.145	0.101	0.0	(d)	12.8	------	------	------	------	------	------	------	------	------	------	Do.
32	290.0	------	------	0.188	0.113	0.0	0.0	14.3	------	------	------	------	------	------	------	------	------	------	Do.
33	278.0	------	------	0.164	0.130	(d)	(d)	12.8	------	------	------	------	------	------	------	------	------	------	Do.
34	264.0	------	------	0.034	0.063	(d)	(d)	3.4	------	------	------	------	------	------	------	------	------	------	Do.
35	260.0	------	------	0.048	0.048	0.0	0.0	3.4	------	------	------	------	------	------	------	------	------	------	Do.
36	235.0	------	------	------	------	------	------	6.2	0.0	161.0	(ad)	132.0	90.0	------	(d)	[b]25.0	[c]10.8	89.2	Peña.
37	235.0	------	------	------	------	------	------	8.2	0.0	167.1	(ad)	137.0	85.0	------	(d)	[b]25.0	[c]10.8	89.2	Do.
38	235.0	------	------	------	------	------	------	6.2	0.0	164.5	(ad)	143.0	90.0	------	(d)	[b]22.0	[c]10.8	80.5	Do.
39	235.0	------	------	------	------	------	------	6.2	0.0	161.0	(ad)	132.0	90.0	------	(d)	[b]22.0	[c]12.0	83.6	Do.
40	1,513.6	------	------	4.8	0.4	(d)	0.0	628.1	------	------	415.6	------	59.7	3.7	------	55.7	112.8	------	Natividad.
41	384	------	------	0.103	0.004	(d)	(d)	18.4	------	------	8.8	------	93.7	1.7	------	11.7	5.4	------	Do.
42	396	314	82	0.033	0.012	0.0	0.0	9.2	------	------	10.1	------	77.7	11.7	------	53.7	20.8	------	Do.
43	350.0	------	------	------	------	------	------	29.0	0.0	250.1	[a]16.5	205.0	67.0	------	(d)	[b]24.6	[c]2.2	70.5	Peña.
44	436.0	------	------	0.166	(d)	0.0	0.0	16.84	------	------	36.26	------	75.72	1.72	------	31.72	15.1	------	Natividad.
45	456.0	------	------	0.195	0.021	0.0	0.0	19.4	------	------	4.7	------	83.7	3.7	------	27.7	17.9	------	Do.
46	432.0	------	------	0.067	0.024	0.0	0.0	22.8	------	------	26.2	------	75.7	1.7	------	7.7	1.2	------	Do.
47	428.0	------	------	0.096	0.048	0.0	(d)	10.34	------	------	(d)	------	79.7	3.7	------	44.1	------	------	Gana.
48	438.0	------	------	0.130	0.014	0.0	0.0	11.95	------	------	18.4	------	87.7	0.5	------	35.7	13.4	------	Natividad.
49	22	------	------	0.101	0.036	0.0	0.0	12.9	------	------	8.8	------	83.7	0.1	------	29.3	4.9	------	Do.
50	3,834	------	------	0.053	0.486	(d)	0.01	2,155.1	------	------	1.9	------	3.7	15.7	------	249.7	126.5	------	Do.
51	510	------	------	------	------	------	------	39.9	0.0	237.9	[a]5.2	195.0	28.0	------	(d)	[b]71.5	[c]18.4	232.8	Peña.
52	466.0	------	------	0.010	0.169	0.0	(d)	38.04	------	------	17.0	------	47.7	2.5	------	86.9	32.5	------	Gana.
53	1,650	1,428	222	0.024	0.036	1.6	0.03	619.0	------	------	67.8	------	9.7	3.7	------	201.7	73.0	------	Natividad.
54	804	732	72	0.036	0.012	(d)	(d)	157.4	------	------	39.0	------	43.7	1.7	------	141.7	28.1	------	Do.
55	2,283.6	------	------	8.933	0.471	(d)	(d)	854.7	------	------	(d)	------	53.7	1.7	------	179.7	------	------	Gana.
56	2,340.0	------	------	8.162	0.737	0.0	0.0	875.4	------	------	(d)	------	61.3	10.1	------	163.7	96.5	------	Do.
57	1,132	1,084	48	5.792	0.435	(d)	0.0	245.4	------	------	1.9	------	25.7	7.7	------	5.7	0.6	------	Natividad.
58	254.8	------	------	0.070	0.046	(d)	(d)	5.41	------	------	------	------	75.7	1.7	------	43.3	------	------	Gana.

[a] In terms of SO_4.

[b] In terms of Ca.

[c] In terms of Mg.

[d] Traces.

TABLE III.—*Analyses of water from deep wells, 1914*—Continued.

Tracing No.	Total solids.	Fixed solids.	Volatile solids.	Free ammonia.	Albuminoid ammonia.	Nitrates.	Nitrites.	Chlorine (Cl).	Carbonates (CO_3).	Bicarbonates (HCO_3).	Sulphates (SO_3).	Alkalinity ($CaCO_3$).	Silica (SiO_2).	Iron oxide and alumina ($Fe_2O_3+Al_2O_3$).	Iron (Fe).	Calcium (CaO).	Magnesium (MgO).	Total hardness ($CaCO_3$).	Analyst.
59	518			0.122	0.072	(d)	0.0	59.7			1.8		81.7	0.5		17.9	3.5		Natividad.
60	1,306	1,138	168	1.026	0.072	0.0	0.0	282.8			297.6		37.7	15.7		85.7	44.0		Do.
61	742.0	676	66	0.265	0.048	0.0	(d)	173.7			55.3		72.0	(d)		14.0	26.4		Gana.
62	240			0.022	0.010	(d)	(d)	5.4			11.5		39.7	3.7		71.7	14.3		Gana and Peña.
63	1,636			10.3	0.615	(d)	0.0	352.9			5.4		33.7	9.7		11.7	17.3		Natividad.
64	1,356	1,288	68	5.928	0.458	(d)	0.0	249.7			12.2		45.7	9.7		5.7	12.2		Do.
65	626	606	20	0.132	(d)	0.0	0.0	157.4			17.0		65.7	1.7		9.7	3.5		Do.
66	690			0.079	0.004	(d)	0.0	147.2											Do.
67	552			0.091	0.007	(d)	0.0	33.9			1.7		65.7	1.7		13.7	1.7		Do.
68	536			0.089	0.016	0.0	(d)	30.4			3.3		61.7	(d)		7.7	(d)		Do.
69	1,292			0.201	0.086	(d)	0.0	603.7			506.1		43.7	5.7		47.7	19.4		Do.
70	290			0.053	0.038	(d)	0.0	33.6											Do.
71	260			0.070	0.012	0.0	0.0	32.6			21.8		31.7	(d)		1.6	0.0		Do.
72	6	4	2	0.053	0.021	0.0	0.0	1.1											Do.
73	252.5							32.5	0.0	82.9	[a]66.5	68.0	26.0		(d)	[b]1.8	[c]0.0	4.5	Peña.
74	230.0							32.0	0.0	79.3	[a]54.6	65.0	35.0		(d)	[b]1.8	(cd)	4.5	Do.
75	261.0							33.9	0.0	80.5	[a]51.5	66.0	30.0		(d)	[b]1.8	(cd)	4.5	Do.
76	545.0			0.056	0.053	0.0	0.0	134.0			(d)		60.0	7.0		15.0	(d)		Gana.
77	1,275.0							436.8	0.0	563.6	[a]6.0	462.0	10.0		10.0	[b]196.6	[c]32.8	490.6	Peña.
78	488			0.042	0.076	0.59	0.67	30.3			0.0		69.7	21.7		3.7	28.1		Natividad.
79	198			0.067	0.002	0.0	0.0	7.0			0.0		21.7	0.3		5.3	1.7		Do.
80	274.0			0.045	0.009	0.0	0.0	3.2			0.0		3.7	1.7		25.7	4.9		Do.
81	368	344	24	0.031	0.007	0.0	0.0	1.0			7.4		35.7	3.7		41.7	13.6		Do.
82	380.0							8.2	0.0	268.4	[a]1.0	220	45.0		(d)	[b]23.2	[c]5.5	80.6	Peña.
83	200.0							15.5	0.0	70.0	[a]2.1	130	15.0		0.0	[b]5.0	[c]0.0	8.9	Do.

84	175.6	......	......	0.034	0.022	0.0	0.0	11.23	......	......	3.2	......	46.5	4.9	......	23.7	19.3	......	Gana.
85	234	......	......	0.128	0.091	(4)	(4)	42.9	......	......	8.1	......	15.7	1.7	......	9.7	[illegible]	......	Natividad.
86	258	234	24	......	......	(4)	0.0	31.7	......	......	1.3	......	15.7	1.7	......	1.7	[illegible]	......	Do.
87	218	......	......	0.009	0.088	(4)	(4)	8.96	......	......	3.5	......	141.7	7.7	......	27.7	15.8	......	Do.
88	244	......	......	0.026	0.041	(4)	0.048	64.9	......	......	278.0	......	103.7	1.7	......	21.7	12.2	......	Do.
89	240	......	......	0.015	0.044	(4)	0.67	6.4	......	......	(4)	......	121.7	9.7	......	11.7	0.1	......	Do.
90	250	......	......	0.124	0.066	(4)	0.0	2.97	......	......	......	......	......	......	......	......	......	......	Do.
91	273	......	......	0.012	0.014	(4)	0.0	6.5	......	......	25.7	......	93.7	0.3	......	27.7	37.3	......	Do.
92	240	......	......	0.250	0.014	(4)	0.0	4.0	......	......	1.7	......	111.7	1.7	......	27.7	31.7	......	Do.
93	286	......	......	0.077	0.024	(4)	0.35	5.7	......	......	1.7	......	165.7	1.7	......	6.5	65.7	......	Do.
94	264	220	44	......	......	0.49	0.0	5.4	......	......	8.1	......	87.7	7.7	......	15.7	9.3	......	Do.
95	318	264	54	......	......	0.139	0.0	3.8	......	......	0.0	......	163.7	23.7	......	15.7	9.3	......	Do.
96	360	284	76	......	......	(4)	0.0	23.3	......	......	24.6	......	99.7	1.7	......	29.7	40.4	......	Do.
97	2,316	......	......	0.012	0.016	0.0	0.0	1,034	......	......	179.9	......	21.7	1.7	......	[illegible]	151.1	......	Gana and Natividad.
98	224	......	......	0.026	0.022	0.675	(4)	6.89	......	......	13.7	......	130.74	1.7	......	27.7	6.5	......	Do.
99	222	......	......	0.149	0.021	0.085	0.015	4.61	......	......	14.9	......	102.0	5.7	......	23.7	1.0	......	Natividad.
100	250	224	26	0.009	0.004	(4)	0.0	4.3	......	......	19.7	......	133.7	11.6	......	29.7	7.1	......	Do.
101	388	324	64	0.014	......	(4)	(4)	4.2	......	......	32.4	......	99.7	1.7	......	54.7	14.4	......	Do.
102	242.5	......	......	......	......	......	......	4.2	0.0	124.1	485.5	192.0	93.5	......	(4)	122.5	85.4	72.2	Peña.
103	312.0	266	46	1.262	0.455	(4)	0.0	5.7	......	......	0.0	......	77.7	1.7	......	3.7	1.1	......	Natividad.
104	272.4	......	......	0.007	0.019	0.0	0.0	11.57	......	......	63.7	......	65.7	7.7	......	55.1	7.0	......	Gana.
105	317.4	......	......	0.030	0.014	0.0	0.0	11.23	......	......	3.3	......	31.1	1.7	......	77.7	23.1	......	Do.
106	187	......	......	0.012	0.014	(4)	0.12	6.2	......	......	0.0	......	21.7	......	......	1.7	[illegible]	......	Natividad.
107	180	......	......	0.009	0.014	(4)	0.15	7.3	......	......	0.0	......	17.7	1.7	......	11.7	11.5	......	Do.
108	[illegible]	......	......	0.048	0.062	0.0	0.0	15.3	......	......	......	......	73.7	1.7	......	[illegible]		......	Gana.
109	[illegible]			[illegible]	0.041	0.0	(4)	[illegible]			28.7		[illegible]	3.7		41.7	[illegible]		Do.
110	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	16.8			[illegible]		[illegible]	[illegible]		41.7	[illegible]		Gana and Natividad.
111	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			13.4		[illegible]	[illegible]		[illegible]	[illegible]		Natividad.
112	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]		[illegible]	1.7		[illegible]	[illegible]		Do.
113	[illegible]			[illegible]	[illegible]			9.7			......								Do.
114	[illegible]			[illegible]	[illegible]	[illegible]		[illegible]			[illegible]		[illegible]	[illegible]		[illegible]	[illegible]		Natividad.
115	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			21.2		[illegible]	[illegible]		[illegible]	[illegible]		Do.
116	[illegible]							[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	Peña.

[illegible]

84	159.6	------	------	0.314	0.362	0.0	0.0	11.33	------	------	5.2	------	46.5	4.9	------	23.7	16.3	------	Gana.
85	364	------	------	0.198	0.091	(d)	(d)	43.9	------	------	8.1	------	15.7	1.7	------	9.7	0.0	------	Natividad.
86	358	334	24	------	------	(d)	0.0	31.7	------	------	1.3	------	13.7	1.7	------	1.7	0.0	------	Do.
87	318	------	------	0.009	0.088	(d)	(d)	8.96	------	------	3.5	------	101.7	7.7	------	27.7	15.8	------	Do.
88	244	------	------	0.026	0.041	(d)	0.048	64.9	------	------	278.0	------	103.7	1.7	------	21.7	12.2	------	Do.
89	240	------	------	0.015	0.044	(d)	0.07	6.4	------	------	(d)	------	121.7	9.7	------	11.7	0.1	------	Do.
90	250	------	------	0.164	0.036	(d)	0.0	2.97	------	------	------	------	------	------	------	------	------	------	Do.
91	273	------	------	0.012	0.014	(d)	0.0	6.5	------	------	25.7	------	99.7	0.3	------	27.7	37.3	------	Do.
92	290	------	------	0.250	0.014	(d)	0.0	4.0	------	------	1.7	------	111.7	1.7	------	27.7	31.7	------	Do.
93	286	------	------	0.077	0.024	(d)	0.30	5.7	------	------	1.7	------	105.7	1.7	------	6.5	65.7	------	Do.
94	264	220	44	------	------	0.49	0.0	5.4	------	------	8.1	------	87.7	7.7	------	15.7	9.3	------	Do.
95	318	264	54	------	------	0.139	0.0	3.8	------	------	0.0	------	103.7	23.7	------	15.7	9.3	------	Do.
96	360	284	76	------	------	(d)	0.0	29.3	------	------	24.6	------	99.7	1.7	------	29.7	40.4	------	Do.
97	2,316	------	------	0.012	0.016	0.0	0.0	1,034	------	------	130.9	------	21.7	1.7	------	209.7	154.1	------	Gana and Natividad.
98	224	------	------	0.010	0.022	0.675	(d)	6.89	------	------	13.7	------	103.74	1.7	------	25.7	6.5	------	Do.
99	222	------	------	0.149	0.021	0.085	0.015	4.61	------	------	14.9	------	102.0	5.7	------	23.7	10.0	------	Natividad.
100	250	224	26	0.009	0.004	(d)	0.0	4.3	------	------	19.7	------	103.7	11.6	------	23.7	7.1	------	Do.
101	388	324	64	0.014	------	(d)	(d)	40.2	------	------	53.4	------	99.7	3.7	------	59.7	14.4	------	Do.
102	242.5	------	------	------	------	------	------	4.2	0.0	124.4	[a]19.6	102.0	93.5	------	(d)	[b]22.5	[c]5.4	72.2	Peña.
103	312.0	266	46	1.932	0.495	(d)	0.0	9.7	------	------	0.0	------	77.7	1.7	------	3.7	1.3	------	Natividad.
104	272.4	------	------	0.007	0.019	0.0	0.0	11.57	------	------	63.7	------	69.7	7.7	------	58.1	7.0	------	Gana.
105	316.4	------	------	0.050	0.014	0.0	0.0	11.33	------	------	5.3	------	34.1	1.7	------	77.7	23.1	------	Do.
106	187	------	------	0.012	0.014	(d)	0.12	6.2	------	------	0.0	------	21.7	0.0	------	1.7	0.0	------	Natividad.
107	190	------	------	0.009	0.014	(d)	0.15	7.3	------	------	0.0	------	17.7	1.7	------	11.7	11.5	------	Do.
108	266	------	------	0.048	0.063	0.0	0.0	15.3	------	------	------	------	79.7	3.7	------	43.3	------	------	Gana.
109	265.6	------	------	0.053	0.041	0.0	(d)	16.3	------	------	28.7	------	85.3	3.7	------	41.7	4.2	------	Do.
110	266	------	------	0.082	0.048	0.0	0.0	16.8	------	------	25.9	------	85.2	0.5	------	41.7	5.6	------	Gana and Natividad.
111	234	------	------	0.12	0.02	0.0	0.0	0.2	------	------	13.4	------	42.8	0.0	------	49.3	0.1	------	Natividad.
112	250	------	------	0.043	0.024	(d)	0.096	9.74	------	------	10.1	------	39.8	1.7	------	45.7	39.7	------	Do.
113	246	------	------	0.118	0.024	0.0	0.0	9.7	------	------	------	------	------	------	------	------	------	------	Do.
114	306	------	------	0.065	0.041	0.0	0.0	14.3	------	------	65.7	------	85.7	9.7	------	43.7	9.7	------	Natividad.
115	236	------	------	0.171	0.009	(d)	0.08	13.6	------	------	21.2	------	41.7	3.7	------	47.7	8.6	------	Do.
116	515.0	------	------	------	------	------	------	221.0	0.0	51.9	[a]24.5	42.5	35.0	------	(d)	[b]21.4	[c]1.2	57.1	Peña.

[a] In terms of SO_4.

[b] In terms of Ca.

[c] In terms of Mg.

[d] Traces.

TABLE III.—*Analyses of water from deep wells, 1914*—Continued.

Tracing No.	Total solids.	Fixed solids.	Volatile solids.	Free ammonia.	Albuminoid ammonia.	Nitrates.	Nitrites.	Chlorine (Cl).	Carbonates (CO_3).	Bicarbonates (HCO_3).	Sulphates (SO_3).	Alkalinity ($CaCO_3$)	Silica (SiO_2).	Iron oxide and alumina ($Fe_2O_3+Al_2O_3$).	Iron (Fe).	Calcium (CaO).	Magnesium (MgO).	Total hardness ($CaCO_3$).	Analyst.
117	228.8	------	------	0.046	0.070	0.0	(d)	23.1	0.0	112.2	30.3	------	20.8	0.8	------	4.9	0.7	------	Gana.
118	206.0	------	------	0.041	0.026	(d)	0.0	24.9	------	------	------	------	------	------	------	------	------	------	Natividad.
119	198	------	------	0.041	0.019	(d)	0.0	25.4	------	------	------	------	------	------	------	------	------	------	Do.
120	304	------	------	0.024	0.024	0.0	0.0	40	------	------	223.4	------	39.7	0.1	------	0.3	0.04	------	Do.
121	1,438	------	------	0.113	0.007	0.0	(d)	619	------	------	28.0	------	53.7	5.7	------	121.7	57.1	------	Do.
122	1,380	1,168	212	0.381	0.067	(d)	0.0	28.7	------	------	407.3	------	89.7	29.7	------	253.7	65.0	------	Do.
123	1,908	1,642	266	0.225	0.001	(d)	(d)	22.8	------	------	862.2	------	113.7	6.9	------	414.5	76.6	------	Do.
124	1,134	1,010	124	1.014	0.219	(d)	0.0	49.9	------	------	14.9	------	275.7	29.7	------	555.7	30.2	------	Do.
125	1,075	------	------	------	------	------	------	10.0	0.0	408.0	342.0[a]	335.0	97.5	------	15.0	[b]178.8	[c]28.5	436.5	Peña.
126	765.0	------	------	------	------	------	------	103.0	0.0	274.0	[a]65.9	225.0	130.0	------	1.0	[b]71.5	[c]22.9	273.0	Do.
127	403.6	------	------	0.034	0.055	high	(d	119.7	------	------	------	------	46.5	1.7	------	14.9	------	------	Gana.
128	1,422	------	------	0.077	0.0192	(d)	0.029	637.0	------	------	103.4	------	49.7	1.7	------	81.7	78.6	------	Gana and Natividad.
129	710.0	------	------	0.096	0.039	(d)	0.0	332.6	------	------	36.3	------	21.7	3.8	------	37.7	32.5	------	Do.
130	278	------	------	0.118	0.043	(d)	0.0	6.52	------	------	(d)	------	45.7	3.7	------	25.7	2.8	------	Do.
131	460	------	------	0.007	0.076	0.0	0.0	10.8	------	------	14.9	------	87.7	0.1	------	81.3	31.3	------	Natividad.
132	658	------	------	0.12	0.08	3.97	0.0	72.5	------	------	71.1	------	95.7	9.7	------	77.7	0.4	------	Do.
133	368	------	------	0.028	0.014	(d)	0.0	14.0	------	------	2.6	------	87.7	1.7	------	13.7	8.5	------	Do.
134	268	------	------	0.061	0.091	(d)	(d)	54.1	------	------	------	------	------	------	------	------	------	------	Do.
135	432	------	------	0	0.007	0.0	0.0	139	------	------	61.7	------	39.7	3.7	------	7.7	9.7	------	Do.
136	370	------	------	0.043	0.033	0.0	0.0	45.6	------	------	------	------	------	------	------	------	------	------	Do.
137	336	310	26	0.041	0.0	(d)	(d)	17.9	------	------	5.4	------	67.7	3.7	------	5.7	0.6	------	Do.
138	------	------	------	0.054	0.052	0.0	0.0	10.34	12.0	247.2	23.9	------	39.8	8.6	------	4.4	(d)	------	Gana.
139	318	------	------	0.064	0.023	0.0	0.0	11.95	------	------	17.0	------	38.7	0.1	------	1.3	0	------	Natividad.
140	303	290	13	0.041	(d)	0.0	0.0	16.8	------	------	1.9	------	45.7	0.0	------	(d)	(d)	------	Do.
141	325.0	------	------	------	------	------	------	13.0	0.0	170.0	[a]13.2	185.0	20.0	------	0.0	[b]3.6	[c]1.1	7.5	Peña.

142	1,052	---------	---------	0.245	0.016	(d)	0.0	381.5	------	------	15.0	-------	61.7	0.5	------	34.9	15.2	-------	Natividad.
143	676	---------	---------	0.016	0.132	0.284	(d)	8.69	------	-------	0	-------	121.7	5.7	------	19.7	2.0	-------	Do.
144	380	---------	---------	0.019	0.014	0.054	(d)	9.7	------	-------	0	-------	111.7	19.7	------	27.7	10.0	-------	Do.
145	1,300	1,198	102	0.007	0.048	(d)	0.28	518.0	------	-------	43.1	-------	9.7	1.7	------	69.7	53.5	-------	Do.
146	1,880	---------	---------	-------	-------	------	------	764.0	0.0	301.0	103.8[a]	247.5	67.0	------	2.5	[b]72.5	[c]49.2	326.6	Peña.
147	1,550	---------	---------	-------	-------	------	------	478.0	0.0	323.3	[a]57.5	265.0	75.0	------	1.5	[b]180.5	[c]63.2	717.2	Do.

[a] In terms of SO_4.

[b] In terms of Ca.

[c] In terms of Mg.

[d] Traces.

TABLE IV.—*Mineral analyses of Philippine waters, 1914.*

Tracing No.	Laboratory No.	Month.	Locality.	Source.	Total solids.	Nitrates (NO_3).	Nitrites (NO_2).	Oxides of iron and alumina (Fe_2O_3 + Al_2O_3).	Silica (SiO_2).	Sulphates (SO_4).	Carbonates (CO_4).	Bicarbonates (HCO_3).
1	118745	May	Albay, Tivi	Tivi spring	177	----	----	7.6	63.0	26.0	----	----
2	118110	January	Bulacan, Marilao	Artesian well	----	(a)	0	0.75	29.6	15.4	8.6	161.7
3	118761	May	Cebu	Palinpinon spring	----	----	----	----	----	----	----	----
4	117934	January	Ilocos Sur, Danglas	Hot spring	2,113.6	0	5.6	18.6	127.3	965.6	0	21.4
5	118304	February	Manila	City water supply	154	0.203	(a)	1.7	23.7	13.8	0	139.1
6	118570	April	Mindoro, Port Galera	Hot spring	----	----	----	0	79.7	578.9	38.1	976
7	118055	January	Rizal, Caloocan	Artesian well	----	0	0	8.6	39.8	23.9	12.0	247.2
8	118100	do	Rizal, San Juan del Monte	P. B. artesian well	228.8	0	0	0.8	20.8	30.3	0	112.2

Tracing No.	Phosphoric acid (PO_4).	Boric acid (BO_2).	Arsenic acid (AsO_4).	Chlorine (Cl).	Bromine (Br.)	Iodine (I).	Manganese (Mn).	Calcium (Ca).	Magnesium (Mg).	Potassium (K).	Sodium (Na).	Lithium (Li).	Analyst.
1	----	----	----	4.3	----	----	----	11.2	2.9	8.1	19.3	----	Natividad.
2	(a)	(a)	0	17.2	0	0	0	3.7	(a)	3.0	78.9	0	Gana.
3	----	----	----	2,577.5	----	----	----	----	----	----	----	----	Natividad.
4	13.6	----	----	226.6	----	----	----	161.4	6.5	83.5	387.7	0	Gana.
5	(a)	----	----	4.07	----	----	----	31.2	6.5	1.9	12.7	----	Gana and Natividad.
6	----	----	----	518	----	----	----	169.7	217.6	355.1	2,944.7	----	Natividad.
7	0	(a)	0	10.34	----	----	----	4.4	(a)	4.0	107.8	----	Gana.
8	(a)	----	----	23.15	----	----	0	4.9	0.7	(a)	87.0	(a)	Do.

[a] Trace.

TABLE V.—*Analyses of waters from miscellaneous sources in the Philippine Islands.*

Tracing No.	Laboratory No.		Month.	Source.	Physical characteristics.	Total solids.	Free ammonia.	Albuminoid ammonia.
1	118064	Albay, Tivi	January	Hot spring	Odor of H_2S	[a]128.8	0.022	0.199
2	119022	Bohol, Anda, Ilaya	July	"Fuente de Casiac" Spring		[a]278	0.019	0.014
3	119338	Cebu	October	Poro Spring	Normal	268	(e)	0.016
4	119339	do	do	Tudela Spring	do	264	(e)	0.009
5	119540	Cebu, Mactan Island	December	Surface well	Turbid	4,215		
6	117934	Ilocos Sur, Danglas	do	Hot spring	Reddish brown color	[a]2,113.6	4.27	0.616
7	118074	Ilocos Sur, Bantay, barrio Paing	January	Canyau Spring	Normal	173.6	0.034	0.058
8	118260	do	February	do		178.0	0.017	0.072
9	118708	Jolo	May	Taigkasan River		[a]196.0	0.050	0.082
10	118709	do	do	Sablay Puti River		212.0	0.036	0.057
11	118304	Manila	February	Public water supply	Normal	154.0	0.028	0.116
12	118570	Mindoro, Port Galera	April	Hot spring	Smell of H_2S		11.41	0.25
13	119066	Mindoro, Calapan	August	Spring	Normal	486	0.012	0.014
14	118446	Palawan	March	Underground river	Fishy smell	8,688	0.289	0.152
15	118678	Palawan, Puerto Princesa	May	Excavation		554	0.036	0.041
16	118065	Rizal, San Juan del Monte	January	Surface well	Normal	256.4	0.010	0.055
17	118179	Tayabas, Lucena	do	Macaas River		[a]144.4	0.036	0.128
18	119406	Tayabas, Guinayangan	November	Maulawin Spring	Normal	334		
19	118655	Zamboanga	May	Tumaga River		208	0.015	0.024

[a] Blackening on ignition.

[e] Trace.

TABLE V.—*Analyses of waters from miscellaneous sources in the Philippine Islands*—Continued.

Tracing No.	Nitrates (N).	Nitrites (N).	Chlorine (Cl).	Carbonates (CO$_3$).	Bicarbonates (HCO$_3$).	Sulphates (SO$_3$).	Alkalinity as CaCO$_3$.	Silica (SiO$_2$).	Oxides of iron and aluminum (Fe$_2$O$_3$+Al$_2$O$_3$).	Iron (Fe).	Calcium (CaO).	Magnesium (MgO).	Total hardness (CaCO$_3$).	Analyst.
1	0	0	2.5	----------	----------	20.2	----------	62.5	1.7	----------	11.7	(e)	----------	Gana.
2	0	0	9.2	----------	----------	0	----------	15.7	2.5	----------	122.2	3.5	----------	Natividad.
3	(e)	(e)	13.0	----------	----------	6.1	----------	11.7	0.3	----------	131.3	2.1	----------	Do.
4	0	0	11.9	----------	----------	0.5	----------	17.7	1.7	----------	121.7	1.4	----------	Do.
5	----------	----------	1,936.0	0	262.0	[b]201.0	215.0	10.0	----------	(e)	[c]353.2	[d]149	1,509	Peña.
6	0	1.7	226.6	0	21.4	[b]965.6	----------	127.3	18.6	----------	[c]161.4	[d]6.5	----------	Gana.
7	(e)	0	3.4	----------	----------	5.9	----------	30.5	1.7	----------	48.5	14.5	----------	Do.
8	0	0	3.3	----------	----------	6.1	----------	31.7	0.7	----------	54.9	12.2	----------	Do.
9	(e)	0	5.1	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	Natividad.
10	(e)	0	4.3	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	Do.
11	0.046	(e)	4	0	139.1	[b]13.8	----------	23.7	1.7	----------	[c]31.2	[d]6.5	----------	Gana and Natividad.
12	0	(e)	518.0	38.1	976	[b]578.9	----------	79.7	0	----------	[c]169.7	[d]217.6	----------	Natividad.
13	(e)	0	55.8	----------	----------	5.4	----------	71.7	1.7	----------	121.7	14.4	----------	Do.
14	(e)	0	5,559.0	----------	----------	516.6	----------	23.7	3.7	----------	199.7	521.3	----------	Do.
15	(e)	(e)	51.9	----------	----------	19.7	----------	61.7	1.7	----------	179.7	28.8	----------	Do.
16	(e)	0	7.6	----------	----------	(e)	----------	122.1	4.9	----------	27.7	12.4	----------	Gana.
17	(e)	0	6.4	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	Do.
18	----------	----------	22.1	0	320.9	14.2	263.0	4.0	----------	(e)	[c]85.9	11.3	252	Peña.
19	0	0	1.6	----------	----------	7.4	----------	23.7	11.7	----------	45.7	7.8	----------	Natividad.

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[b] In terms of SO$_4$.

[c] In terms of Ca.

[d] In terms of Mg.

[e] Trace.

TABLE VI.—*Field assays of waters from deep wells in the Philippine Islands.*

Tracing No.	Laboratory No.	Location.	Artesian well No.	Depth.	Flows or pumps liters per minute.	Temperature.	Alkalinity ($CaCO_3$)	Iron (Fe).	Sulphates (SO_3).	Chloride (Cl).	Carbonates (Na_2CO_3).	Bicarbonates ($CaCO_3$).	Total hardness ($CaCO_3$).
				Meters.									
1	54	Cebu, Argao, on plaza in front of municipio.			Pumps[a]	28.5	20.0	2.0	43.5	140.7	0	20.0	120.0
2	45	Cebu, Cauit Island		82	do[a]		70.0			8,200.0	0	70.0	220.0
3	63	Cebu, Carcar; Philippine Railroad Co			do		40.0		(b)	29.0	0	40.0	276.0
4	65	Cebu, Carcar; Santa Catalina			do		31.0		26.0	40.0	0	31.0	200.0
5	18	Cebu, Cebu; customhouse			Pumps 227 liters		57.0		(b)	111.0	0	57.0	66.0
6	19	Cebu, Cebu; at carbon public market			Pumps		140.0		(b)	27.5	0	140.0	122.0
7	22	Cebu, Cebu; Bagumbayan		27.5		29			(b)			27.5	
8	23	Cebu, Cebu; Calles Lapulapu and Manalili.			Pumps	29.5	66.6	2.0	82.0	89.0	35.3	33.3	68.0
9	44	Cebu, Cebu; next to 114 Juan Luna			do		60.0			19.4	0	60.0	262.0
10	29	Cebu, Toledo	689	55	do		68.5	4.5	18.0	124.0	0	68.5	244.0
11	73	Iloilo, Iloilo; Plaza Libertad	[d]511	63	Flows[a]		72.5	4.0	0	870.0	0	72.5	370.0
12	75	Iloilo, Iloilo; Landon mess	[d]523	65	Pumps	40	35.0	2.0	0	1,060.0	0	35.0	442.0
13	76	Iloilo, Iloilo; Calles Lanao and Yznart	[d]592	80	Flows 16 liters	29	51.0	2.0	0	930.0	0	51.0	240.0
14	77	Iloilo, Iloilo; Convent Assumption Sisters.	428	78	Flows 18 liters	29	31.0	4.0	0	790.0	0	31.0	234.0
15	66	Iloilo, Iloilo; Molo	480	91	Flows 3 liters	28.7	89.5	2.2	0	376.0	0	89.5	230.0
16	67	do	580	55	Flows 37 liters		72.5	1.0	(b)	600.0	0	72.5	400.0
17	100	Iloilo, Janiuay; at plaza			Flows	28.5	51.7	(c)	0	12,155.0	0	51.7	274.0
18	71	Iloilo, Jaro; at plaza			do	30	58.0	(c)	0	1,430.0	61.5	0	46.0
19	70	Iloilo, Mandurriao; Calles R. Papa and Cementerio.	490	87	Pumps 113 liters	28.7	37.5	2.5	0	318.0	34.8	12.5	58.0
20	102	Iloilo, Santa Barbara; on plaza		152	Flows 28 liters	29	75.0	(c)	0	242.0	60.5	17.5	17.0
21	3	Mindoro, Calapan; at public market		24		40	440.0	10.0		1,040.0	0	440.0	

[a] Slight flow at high tide. [b] Trace. [c] High. [d] All Iloilo deep-well waters are yellow.

TABLE VI.—*Field assays of waters from deep wells in the Philippine Islands*—Continued.

Tracing No.	Laboratory No.	Location.	Artesian well No.	Depth.	Flows or pumps liters per minute.	Temperature.	Alkalinity. (CaCO$_3$)	Iron (Fe).	Sulphates (SO$_3$).	Chloride (Cl).	Carbonates. (Na$_2$CO$_3$).	Bicarbonates (CaCO$_3$).	Total hardness (CaCO$_3$).
				Meters.									
22	11	Mindoro, Naujan; at presidencia		54	Flows 18 liters	30	44.0		10		24.0	22.0	low
23	12	Mindoro, Naujan; 100 meters west of presidencia.		55	Flows		57.0				30.0	28.5	
24	13	Mindoro, Naujan; near seashore		67	do		50.0				21.0	30.0	
25	10	Mindoro, Pinamalayan; new townsite		54	do		20.0	(b)	22		0	20.0	60.0
26	8	Mindoro, Pola; near presidencia		6	Pumps		160.0				0	160.0	174.0

[b] Trace.

TABLE VII.—*Field assays of spring waters in the Philippine Islands.*

Tracing No.	Laboratory No.	Location.	Source.	Temperature.	Alkalinity $(CaCO_3)$.	Iron (Fe).	Sulphates (SO_3).	Chlorides (Cl).	Carbonates (Na_2CO_3)	Bicarbonates $(CaCO_3)$.	Total hardness $(CaCO_3)$.
				°C.							
1	111	Capiz, Capiz; near railroad terminal	Spring and pool	------	46.8	0.35	125.0	85.0	0	46.8	106.0
2	56	Cebu, Argao	Kabagohan Spring	------	33.4	------	(a)	5.5	0	33.4	318.0
3	35	Cebu, Asturias; southeast of town; 1 kilometer from municipio.	Spring	------	50.0	1.4	(a)	16.5	0	50.0	180.0
4	34	Cebu, Balamban; barrio Cambojaue	Spring	------	30.8	(?)0.5	(a)	77.0	0	30.8	230.0
5	61	Cebu, Carcar	Guadalupe Spring	26.5	30.8	0.5	(a)	11.0	0	30.8	214.0
6	21	Cebu, Cebu; beach near leper hospital	Springs	30	------	2.0	(a)	148.5	0	------	------
7	47	Cebu, Minglanilla; about 200 meters northeast of schoolhouse.	do	------	53.0	0.5	(a)	14.0	0	53.0	200.0
8	48	Cebu, Naga	Jugan Spring	29	49.0	0.3	32.0	142.0	0	49.0	232.0
9	58	Cebu, Sibonga	Spring	------	33.4	(a)	(a)	37.0	0	33.4	222.0
10	104	Iloilo, Santa Barbara; at golf club	do	------	66.7	------	(a)	8.0	0	66.7	131.0
11	1	Mindoro, Calapan; 4 kilometers back of town	do	30	405.0	0.25	------	55.0	0	405.0	420.0

[a] Trace.

TABLE VIII.—*Field assays of surface waters in the Philippine Islands.*

Tracing No.	Laboratory No.	Location.	Source.	Depth.	Temperature.	Color.	Turbidity (SiO_2).	Alkalinity ($CaCO_3$).	Iron (Fe).	Sulphates (SO_3).	Chlorides (Cl).	Carbonates (Na_2CO_3).	Bicarbonates ($CaCO_3$).	Total hardness ($CaCO_3$).
				Meters.	°*C.*									
1	42	Capiz, Capiz; in front of church	Surface well	2		0	0	53.5	0.13	46.0	95.0	0	53.5	180.0
2	114	Capiz, Dao	Concrete sump			100	(a)	33.4	2.7	0	8.0	0	33.4	66.0
3	117	Capiz, Dumarao; south of town	Sump			25	(a)	50.0	1.5	27.5	11.5	0	50.0	152.0
4	52	Cebu, Argao; at market place	Surface well	1.5		0	0	50.0		35.0	44.5	0	50.0	282.0
5	53	Cebu, Argao; at convent	do	1.5	28	0	0	54.5			82.5	0	54.5	334.0
6	55	Cebu, Argao; at municipal building	do					33.4			109.0	0	33.4	318.0
7	36	Cebu, Balamban; about 2 kilometers from Balamban, road to Asturias.	Combado River			0	(a)	34.6	1.4	(a)	7.0	0	34.6	186.0
8	37	Cebu, Balamban; on plaza	Surface well	3		0	(a)	51.0	1.0	(a)	88.5	0	51.0	232.0
9	62	Cebu, Carcar; Calle San Jose	do					33.4			42.0	0	33.4	294.0
10	64	Cebu, Carcar; No. 22 Calle S. Vicente.	do					33.4		23.0	23.0	0	33.4	342.0
11	16	Cebu, Cebu; Buhisan	Osmeña Waterworks		31	0	0	50.0	2.6	67.0	6.0	0	50.0	202.0
12	17	Cebu, Cebu; No. 57 Calle Colon	Surface well	5	27.5	0	0	77.0	1.4	(a)	25.0	0	77.0	100.0
13	20	Cebu, Cebu; near the Southern Island Hospital.	do		29	0	95.0	50.0	1.0	(a)	13.5	0	50.0	256.0
14	40	Cebu, Cebu; No. 193 Colon	do	4				47.0			51.5	0	47.0	268.0
15	41	Cebu, Cebu; No. 114 Juan Luna	do	2				70.5			203.0	0	70.5	454.0
16	42	Cebu, Cebu; Calles Manalili and N. America.	do	2.5				45.0			25.5	0	45.0	220.0
17	46	Cebu, Minglanilla; near market	do	9		0	0	51.0	3.4	(a)	41.0	0	51.0	258.0
18	49	Cebu, Naga; Calles Rizal and Buencamino.	do	2		0	0	54.5	0.3	129.0	254.0	0	54.5	358.0
19	50	Cebu, Naga; at convent	do					50.0		76.0	254.0	0	50.0	266.0
20	51	Cebu, Naga; on provincial road	do	2.5				54.5			144.0	0	54.5	232.0
21	57	Cebu, Sibonga; No. 1 Calle Burgos	do					51.0			320.0	0	51.0	454.0
22	59	Cebu, Sibonga; Saba	do	1							16.5			

23	60	Cebu, Sibonga; near municipio	do	--------	--------	--------	--------	--------	--------	--------	156.0	--------	--------	200.0
24	28	Cebu, Toledo; on plaza opposite municipio.	do	4	--------	0	(a)	49.0	(a)	(a)	148.0	0	49.0	300.0
25	30	Cebu, Toledo	Grande Subak River	1	--------	0	80.0	50.0	5.0	125.0	13.5	0	50.0	220.0
26	31	Cebu, Toledo; Espeleta	Surface well	1	--------	0	(a)	60.0	2.5	(a)	35.5	0	60.0	322.5
27	32	Cebu, Toledo; Calle Fermin Polayapoy.	do	6	--------	0	0	50.0	--------	--------	111.0	0	50.0	368.0
28	33	Cebu, Toledo; Calle Adriano Blanco	do	--------	29	0	0	47.5	--------	--------	68.0	0	47.5	344.0
29	69	Iloilo, Iloilo; Plaza Libertad	do	2	--------	--------	0	54.5	1.0	350.0	790.0	0	54.5	440.0
30	87	Iloilo, Iloilo; at Army post	do	6	--------	0	113.0	44.5	(b)	600.0	8,150.0	26.5	19.4	820.0
31	88	Iloilo, Iloilo; at the Trade School	do	6	?27	0	0	50.0	0	11.0	71.0	0	50.0	212.0
32	89	Iloilo, Iloilo; near Assumption College.	do	3	--------	100.0	0	52.5	1.0	500.0	805.0	31.6	19.7	52.0
33	105	Iloilo, Iloilo; Molo, Calle Antigua No. 2.	do	1	--------	0	0	62.5	--------	(b)	480.0	0	62.7	394.0
34	106	Iloilo, Iloilo; Calles Ortiz and J. M. Basa.	do	2	--------	0	0	54.5	--------	53.0	57.0	0	54.5	192.0
35	107	Iloilo, Pototan; behind Bureau of Public Works automobile shed.	do	2	--------	0	0	51.7	1.3	38.0	42.0	0	51.7	182.0
36	108	Iloilo, Pototan; behind tienda opposite railroad station.	do	4	--------	0	0	50.0	2.3	96.0	27.0	0	50.0	200.0
37	109	Iloilo, Pototan; Calle Jaena, adjacent to municipio.	do	3	--------	0	0	46.0	1.7	73.0	85.0	0	46.0	282.0
38	103	Iloilo, Sta. Barbara; No. 16 Calle Magalona.	do	1.5	--------	0	0	58.7	0.7	73.0	290.0	0	58.7	374.0
39	7	Mindoro, Pola; 50 to 75 meters from beach.	Driven well	5.5	--------	0	0	300.0	--------	--------	--------	0	300.0	369.0
40	9	Mindoro, Pinamalayan; 2.5 kilometers beyond town.	River	--------	--------	0	0	--------	(a)	0	--------	0	60.0	93.0
41	5	Mindoro, Pola	Tiguihan River	--------	27.5	0	(a)	--------	0.1	0	--------	0	60.0	65.0
42	2	Mindoro, Calapan	Surface well	5	--------	0	0	--------	--------	--------	110.0	--------	--------	--------

[a] Trace.

[b] Very high.

REVIEWS

Cocoa | by | Dr. C. J. J. van Hall | director of the Institute for Plant-Diseases and Cultures, | Buitenzorg, Java | with illustrations and map | Macmillan and Co., Limited | St. Martin's Street, London | 1914 | Cloth, pp. i-xvi+1-515.

The Coco-nut | by | Edwin Bingham Copeland | professor of plant physiology and dean of the | College of Agriculture, University of | the Philippines | Macmillan and Co., Limited | St. Martin's Street, London | 1914 | Cloth, pp. i-xiv+1-212.

The literature of tropical agriculture has been notably enriched by the appearance of these two new works. The development of tropical agriculture during the past twenty-five years has presented many interesting and noteworthy features. It has differed markedly from the development of temperate-region agriculture, and it has been able to borrow comparatively little from the latter. Many of its crops are entirely peculiar to the tropics, and tropical conditions furnish a series of wholly unique problems. Tropical planters have had to feel their way by painful steps, gradually gaining the local experience necessary for successful, practical operations. Even this kind of development has been far more rapid than in the case of temperate region agriculture, largely due to the fact that tropical agriculture has been characterized by the investment of large capital. The capital invested gradually drew to its service well-trained technical men from the temperate countries. In late years the establishment in colonial possessions of active agricultural experimental stations has given a great impetus to the development of the technical side of tropical agriculture. Much of the early literature of tropical agriculture consisted of accounts of the personal experiences in tropical planting of untrained men, some of whom, however, in the school of hard experience finally became very successful planters. Until within the last decade really high-grade technical works on tropical agriculture were very few, and even yet works like Semler's Tropische Agrikultur and Warburg's Die Muskatnuss remain very rare.

There is the same difference between the mass of the earlier literature and these later works as exists between a farm school and a college of agriculture. The methods of the farm school are those of formula and precept, largely of only local application. The students of the farm school cannot receive the basic scientific training which would enable them either to coördinate or to generalize their results safely, or to understand clearly the reasons back of their practical operations. As Doctor van Hall clearly shows, many of the cacao "experts" of former years commonly failed in this. On the other hand, the college of agriculture requires a thorough preparation in the sciences basic to agriculture, in order that its students may be able to apply more or less sound reasoning to all agricultural phenomena and problems that may present themselves, and also enable them to adapt their practice and learning, on the basis of intelligent ratiocination, to a wide range of natural conditions. The unexpected is the daily diet of the tropical planter.

The two books under consideration well represent the college grade of tropical agricultural science. They are exceedingly rich in the application of modern science to the growing of two very important tropical crops. They probably represent the highest development yet attained in the agronomy of any tropical crop. In a number of otherwise great special works on tropical agriculture this aspect—the art and science of producing the crop—has been seriously neglected, due largely, of course, to the lack of the exact data that can only be obtained by comprehensive and long-continued experimentation. This is characteristic of works on cane, for example, in which the manufacturing side has received the major attention; although, with the highly important results of the past few years, a good preliminary text on the agronomy of cane is now for the first time possible. In a recent very extensive work on cacao only 20 pages are devoted to the entire agronomy-side of the subject. While the two present works represent the latest and most complete results in the agronomy of these crops, still, all through their pages there are encountered references to points and problems yet unsolved. Doctor van Hall's work is particularly valuable in that it includes a critical review, characterized by clear thinking and technical treatment, of all important previous works on cacao. Such an attempt to coördinate and explain the great diversity of former opinion is of the highest possible importance in the development of tropical agriculture. Formerly the planter or student was quite lost in the maze of diverse local opinion, unless, perchance, there happened to exist works relating to operations in his own locality. Doctor van Hall makes available to the student and to the planter the well-digested results from all regions, although he says nothing calculated to minimize the great importance of local experience. On the contrary, in his preface he remarks: "This does not mean that the intention of the book is to teach the reader cocoa-planting, and it is not expected that anyone unacquainted with cocoa-culture will become a cocoa-planter by reading the book from beginning to end." Again, he remarks very aptly that "often the practical man knows *how* he has to treat his trees or his soil in order to get his best result, but not *why*." He further explains that there are many things which "cannot be learned in the field," and this is a point sometimes lost sight of by some too obstinately "practical" men—men who still harbor the antiquated falsity that any line can be drawn between "science" and "practice."

In Doctor van Hall's full account of the development of cacao culture in many countries one finds of very live interest the description of the peculiar methods of culture in Surinam, and the story of the growth of the industry in the Gold Coast. In the latter country we probably have one of the most remarkable examples in existence of the possible influence of foreigners upon the agricultural development of an essentially primitive people. In 1901, 80 kilograms of cacao were exported from the Gold Coast. In 1911 the country produced more than 40,000,000 kilograms; however, this does not mean the result of investment of large capital, but development of the common people. This evidence of real results in practical colonial agricultural development is one to which we can unfortunately offer no remote parallel in the Philippines, where the people possess a country naturally adapted to cacao, but where they do not yet produce enough to supply their own local needs, and this nearly two hundred fifty years after its successful introduction! A thousand copies, at least, of Doctor van Hall's book should find readers in the Philippines.

Doctor Copeland's book is a splendid example of scholarly and scientific treatment. It is, perhaps, the best case extant in a work on any single major tropical crop of the application of modern biological methods to all the details of the agronomical side of the subject. An innovation in this work, of the highest possible importance, consists of a thorough consideration of the physiology of the coconut tree. There is no doubt but that this will prove an epoch-marking event for the agronomy of all crops and of all countries. We would have little respect for a system of medicine, or confidence in its methods, in which there was no provision for thorough technical study of the physiology of the human body, yet the agronomy of most tropical and many temperate crops is exactly in this condition—the details of the life operations of the plants in question, as to their foraging ability, food elaboration, water requirements, transpiration habits, organic reaction to surrounding conditions, and specific reaction to disease, being unknown. The experience of the practical planter is one continuous struggle with serious problems, many of which might easily be solved through fuller knowledge of the detailed physiological operations and needs of the plant he is attempting to grow. It seems that if anything is to be expected from real colleges of agriculture as distinguished from farm schools, and more particularly expected from colleges of agriculture in universities, it is a thorough grounding in these basic lines of work that shall enable students to approach the practical problems of agronomy with broad intelligence and really adequate equipment. In this connection Doctor Copeland's book furnishes the best example of what a textbook for a college of tropical agriculture should be. His work is, of course, not final in any respect, and he clearly recognizes, as does Doctor van Hall, that the science of tropical agronomy is an extremely undeveloped one. In the face of this fact some temperate-region agronomists do not seem to be able to understand why things should not be done thus and so in the tropics—along lines well-established in temperate regions. The light will not dawn upon such, or rather the knowledge of the lack of light, until they join the ranks of pioneers in a new tropical country and undertake the practical establishment of well-ordered cacao or coconut plantations. It is evident, for instance, in Doctor Copeland's discussion of fertilizers, that the subject is still an open one, no comprehensive experiments having yet been carried through a sufficiently long term of years. The subject of the seed selection of the coconut still requires thorough investigation and experimentation. Doctor Copeland does not mention the interesting case of the small island of Rotumah in the South Seas, which is said to produce coconuts of unusual size and value. These coconuts, in years past, are said to have been used extensively for the establishment of plantations in other islands, some being reputed to have brought as much as a shilling apiece as seed. It would be a matter of the highest interest and importance to trace the results obtained from these seeds in other islands and under other conditions.

The immediate effect of Doctor Copeland's book will be the stimulation of students, planters, and investigators to more acute attention to scientific methods in the solving of the very numerous problems in coconut culture. It should be a matter of pride to the University of the Philippines that it has furnished to the world so notable a work of this character.

Many will disagree with Doctor van Hall on the use of the word "cocoa." The original Mexican name of the plant is variously given as "cacahuatl," "cacaguata," or "caquahuitl," and the original Spanish derivative was "cacao." The last form seems to be in very wide use, especially in the Spanish-speaking countries. "Cocoa" is the name commonly applied to the fat-free breakfast powder, and might well be restricted to that application. Nor will everyone agree as to the need of a hyphen in the word "coconut."

In both of these books the treatment of fungous diseases and insect pests is especially complete and practical, and this feature alone would make the appearance of the two works exceedingly opportune. Doctor van Hall's treatment of the subject of cacao varieties is unquestionably far in advance of any yet presented.

The typographical work in both books is admirable, the type being large and clear, and the illustrations—with which both works are replete—being on the whole of exceptionally good quality. The paper used in Doctor van Hall's book is of a much better grade than that in Doctor Copeland's. Both works seem to be remarkably free from typographical errors, the few which do occur rarely confusing the sense, and these few will be corrected in succeeding impressions.

C. F. BAKER.

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